Metallurgical and Chemical Engineering

Contents for April 1, 1917

Gas versus Waterpower

If the keynote of modern industrial development is multiplication of individual human effort by power provided by nature, the mobilization of the industrial forces of a country comprises not only the men, but the natural power resources. The two principal ones are coal and waterpower. At the waterpower conference of the American Institute of Electrical Engineers and of the American Electrochemical Society a year ago in Washington it was brought out by the late H. G. Stott that in the present status of technical advance and with present conditions of financing power projects, steam is cheaper than waterpower up to a 60 per cent load factor. This statement emphasizes two facts. First, that waterpower is the power par excellence of all industries with very high load factor, such as the electrochemical and electrometallurgical industries. Second, the immense progress made in recent years by steam engineering is emphasized. Yet no finality has been reached in this direction as indicated by the very suggestive article by Capt. H. G. H. Tarr, published on page 373 of the present issue. His scheme is a novel one. It is to use the by-product gas producer, but to combine it not with the gas engine but with gas-fired steam boilers and steam turbines. It is noteworthy and deserves attention.

The Steel Corporation's Interesting Report

A year ago, in reviewing the United States Steel Corporation's report for the calendar year 1915, we referred to it as "the record of a wonderful year," not by any means wonderful as to the totals involved, but noteworthy as to the sweeping change that occurred, from operations at less than 50 per cent of capacity to operation at capacity, and more than rated capacity in the case of some departments.

The year 1916, for which the report has just been published, was a great year for tonnage and a wonderful one for profits. It was the first year since 1906 in which the steel industry operated at capacity for a full calendar twelvemonth. The corporation's output, in steel products for sale, was 15,460,792 tons, showing that despite the freight congestion toward the close of 1916 the corporation was able to reduce its stocks during the year by 81,296 tons.

The production in 1916 discloses quite closely the actual capacity, the average for the year or, generally speaking, the capacity on July 1, 1916. We have it that in the report for 1908 the capacity on April 1, 1901, the date the corporation began business, the capacity was 7,719,000 tons, and this checks with the fact that in 1902, operating at substantially capacity, and with additions to capacity, the actual production was 8,033,556 tons. To be more precise than accurate, in a period of

15 years and three months the capacity increased by 100.3 per cent. To be accurate and concise, the capacity doubled in 15 years. Of the increase, 19.5 per cent was due to the purchase of the Union, Sharon and Tennessee companies. The purchase of the Troy Steel Products Company did not add to capacity, as the plant was not bought to operate, nor was it operated.

Deducting from the total iron and steel exports of the United States the exports of scrap, pig iron, iron bars, cast-iron pipe and radiators, one has left what amounts substantially to the regular steel exports, comprising such items as the Steel Corporation reports as its steel exports. Apart from these it exports a little scrap and pig iron. The change effected by the buyer coming to the seller in these war times offering New York funds, not merely against vessel bill of lading but even against railroad bill of lading, is well illustrated by the comparison made below, of the country's exports and the Steel Corporation's exports:

	Corporation.	United States.
1912	2,233,570	2,531,131
1913	1,756,328	2,323,632
1914	1,096,234	1,387,296
1915	2,350,524	3,123,820
1916	2,466,793	5,131,261

In 1912 and 1913 the Steel Corporation's proportion of the total exports was 82.2 per cent, and the 17.8 per cent attributable to independent manufacturers was doubtless chiefly business done with Canada, hardly less difficult, so far as concerns the selling machinery, than strictly domestic business. In 1916 the Steel Corporation's proportion was only 48.1 per cent. When export business was difficult, and price concessions were common, the independents were quite content to allow their great and good friend to do the business. When the sales could be effected at the home office, for spot cash, and frequently at higher prices than ruled in the domestic market, the independents graciously accepted more than half the business going.

The Steel Corporation's profits in 1916 need not be considered at length, for 1916 represented merely a chance grouping of 12 consecutive months, in the last of which the profits per ton were more than double those in the first. The corporation's total earnings in the twelvemonth ended Dec. 31, 1916, after payment of interest on subsidiary company bonds, were $333,574,178. If the fiscal year had ended three months earlier the earnings would have been about $55,000,000 less, while if it ended three months later they would have been approximately as much more. The amount passed to book surplus was $201,835,585, or one-fourth more than the total earnings in the best previous year, 1907. There were no appropriations for improvements, though there were expenditures of some $65,000,000 for improvements chargeable to capital account, part of the funds being provided by previous appropriations and by transfers from depreciation accounts.

The maximum production of Bessemer steel ingots by the Steel Corporation occurred in 1906, with 8,972,655 tons. In 1916 the production was almost as large,

7,273,766 tons. Meanwhile the Bessemer departments at both the Homestead and Duquesne works had been abandoned entirely. The production of open-hearth ingots increased in the ten years from 5,438,494 tons to 13,636,823 tons.

Industrial Evolution

Within the knowledge of mankind there has never been a time when the civilized world has been making such wonderful strides toward man's humanity to man, as are brought to view every day in the handling of the labor problems in our large industries. For many years the inventive genius of the age has devoted itself to the perfection of machinery, and processes by which labor could be made more productive, always having in mind the elimination of the human hand; but time has demonstrated that no matter how perfect the mechanism, the human hand and mind are always needed; and it has gradually dawned upon the directing heads of our large corporations that, after all, their first great problem is the study of their workman, and the means necessary to make of him the one essential necessary to success—a thinking machine.

Darwin spent much time and thought upon the evolution of man from the monkey, but always failed to find the missing link, but to those of thoughtful mind there is no missing link when it comes to the study of the present-day labor conditions. In early times when the human race was unorganized and dependent on its individual efforts for food, it is very easy to see why might made right, and why to the victor went the spoils, and to a great extent that doctrine has survived to the present day. It has taken all the blood shed in Europe to bring to the minds of men in this country the idea that after all we are our brother's keeper, and that in just so much as we help our fellows so do we help ourselves. Thus we see the great spirit of co-operation taking its hold on the minds of people so that to-day we see men no longer work for a concern, but rather with it. What greater sign of the times can be seen than the sign in the New York subway, "We ask your help"? How would the directors of that corporation have felt about such a sign ten years ago?

Evolution, the great change, is necessarily coming slowly, but in this country particularly, with its great masses educated sufficiently to grasp the fundamentals of the human doctrine, "Thou shalt love thy neighbor as thyself," we will be nearing a social millennium. Lying, stealing, etc., are going out of fashion, selfishness brings quick retribution, and to-day the employer asks how he can give to those working with him so square a deal that the employee will feel it and be inclined to return good for good, just as in the past he has tried to return evil for evil.

If this country is to maintain its industrial supremacy it must be done by every man, woman and child doing their part to see that whatever task they have in hand must be done to the very limit of their ability, and our great corporations must set the example of careful training, fair remuneration and square dealing, and our in-

dustrial preparedness will be a success. No matter how much we may plan and train our people for some great cataclysm, it will come to nothing if we cannot make every individual see that they must do right for the sake of right, and the country whose people are firm believers in a religion which teaches them that to-day is the important day of their lives, and that they will be held accountable for mistakes right here on this earth, is the country which must surely dominate the world in the end.

Preparation for anything great or small is wise, and that preparation which teaches children so to live that their children may be greater than their parents are is the type of preparation which says that that people shall not perish from the earth. Nature works slowly, and it will take thousands of years and the bloodshed of many martyrs before the human race reaches a point where the lion shall lie down with the sheep; but we can each do something to see that our lives are so lived that we at least have helped to push along that mental evolution which is going on and has been going on ever since the cave man learned to make a fire with sticks.

Barriers to Progress

Despite all the efforts that have been made to bring about real democracy, despite all the dreams of a better social state and despite patents, the fact remains that useful inventions are about the hardest things there are to sell. The presence and increase of research laboratories have not aided in this respect.

A corporation is organized for the purpose of making money for its stockholders; it would not be organized if there were not a lively hope of this, and all the hue and cry against the desire of corporations to make profits is based upon defective psychology. This is so self-evident that we should hesitate to repeat it if it were not for the fact that we want to set it forth as a basis for what follows.

In the research laboratory of a manufacturing corporation the chemists, physicists and engineers address themselves to problems of saving expense, improving methods and bringing out new products, all with a view to eventual profit. To do this is sound and reasonable. It is also easy to understand that an invention that has its origin outside of the laboratory or works will not find the same welcome there that "a little thing of our own" does.

The outside invention coming from an unknown inventor is, so to speak, born poor. And the inventor may be a patent thief, which would make him fair game for anybody's boot. One never can tell; there are a great many of them at large. If a corporation is in dire need of an invention which originated outside of its aegis, there is a good chance for barter and sale. On the other hand, an invention of great economic value and sorely needed by society at large, may languish unused and unavailed of for years and years if the industry to which it pertains is not prodded into adopting it.

The public is the last to demand betterment. It does not know, is not scientifically informed, and nine times out of ten it regards waste as progress. It hates anything new, although it has faith that the last cry is perfection and 100 per cent yield. It only becomes incredulous at such times as when told that oleum is "more than 100 per cent sulphuric acid." The public does not know where savings may be made, and when it is not profitable to industry as it is organized to make a saving, the chances are that the waste will continue. Chemistry has not yet succeeded in teaching the public that waste is wrong; therefore, inventions that provide for no immediate profit to industry over the methods in vogue are almost impossible to sell. Another handicap lies in the fact that an invention is an invention; previous efforts to do this very thing have failed; the sum of human experience teaches us that it cannot be done; ergo, the inventor is an ass.

We published lately an article on the need of substituting nitro-aromatics for nitro-glycerin in commercial explosives. Without doubt many manufacturers would be willing to furnish nitro-aromatics and be glad to do so if the public would only take it; but the public still wants dynamite no matter what the cost. And now along comes nitro-starch, very much needed but doubtful if wanted by the public without educational pioneer work.

The inventor of a two-cycle explosion engine might rather solicit life insurance or try to sell Sermons of Cotton Mather than undertake to dispose of his patents. Everybody knows that the two-cycle engine is not worth looking into because it has always been a failure. And yet there is the idea, bound to come some day with nearly double the power for the same weight of machinery.

There is a method of tanning sole leather which makes it endure over twice as long as the best quality available to-day. It is not a very expensive process, but it is different and requires a new layout. Only a little of it is produced occasionally in a school of tanning and the product is bought up by a small leather dealer near by. He in turn sells it to neighboring cobblers who know leather but are not astute business men. They have spoiled their customers, who are not satisfied with ordinary sole leather any more. The rest of us cannot get that leather, and shoe manufacturers have shown no great desire to use it. Nevertheless, it would make shoes last longer, and we are, in effect, in the midst of a leather panic.

There doesn't seem to be any way to get desired inventions into use unless they are needed by manufacturers for immediate profits. At first thought the law of supply and demand seems to break down here, but we venture the opinion that this is not the case. The need for these inventions is present but the demand for them is not uttered. There is too little scientific public opinion abroad to assess their value. If we only had a more enlightened public opinion the real inventor would have a better chance. And his work would be of benefit to all of us.

Readers' Views and Comments

The United States in the Realm of Research

To the Editor of Metallurgical & Chemical Engineering

Sir:—The bibliography of alloys by Clarence Estes, published in the March 1, 1917, issue of Metallurgical & Chemical Engineering, should satisfy a long-felt want, not only by reason of its completeness but also because it brings the works of Desch and others up to date. This bibliography again brings rather forcibly to mind the relative position of this country in the realm of research. A rough calculation shows the percentages of the number of articles contributed by the workers of different countries based on the references in the periodicals in which the writings were first published. These percentages are as follows: Germany 50 per cent, France 16.3, England 12.2, United States 6.6, Russia 5.3, Italy 4.9, joint (in which investigators from different countries took part) 3.0, Japan 0.7 and Canada, Scotland, et al. in disappearingly small amounts.

Thus it appears that of the investigations dealing with the equilibria of alloy systems some 50 per cent have been the result of Teutonic labors. The position of the United States standing slightly ahead of Russia and Italy is somewhat painful to contemplate. In only the work on the iron-carbon system have the investigators in this country stood out prominently. It would seem in the light of the immense practical value of the metallic alloys as though more work would have been performed in the United States. There is no doubt a great deal more research going on at the present time than the aforementioned record would indicate, but some of it is unquestionably suppressed and does not find its way into the scientific press in anything like due season.

I have in mind a paper read before one of the societies not long ago which was then given out a number of years after the subject discussed had been in successful operation. The item alluded to was fully protected by patent as well as a strong corporation, yet the cause of delay was "for commercial reasons." It is presumed that the wide publicity which research requires will be secured with passing time.

Cleveland, Ohio. ROBERT J. ANDERSON.

The Application of Nitro-Aromatics in the Explosive Industry

To the Editor of Metallurgical & Chemical Engineering

Sir:—I have read with interest the article, "The Application of Nitro-Aromatics in Explosive Industry," by John R. Mardick in your issue of March 15, 1917.

I agree with Mr. Mardick that a commercial explosive having nitro-aromatics as a base has a bright future. However, he states: "No serious efforts have been made in this country to make explosives containing other than N.G. True, there have been spasmodic attempts here and there by amateurs," etc. This is not true, since commercial explosives of this class have been developed by experts and large quantities of them have been consumed. They did not succeed on account of financial difficulties, but, on the other hand, the explosive chemist concerned in their manufacture produced a wonderful product.

It is also natural that the manufacturers of nitroglycerin and its products do not look with favor on a product which can be manufactured more cheaply and which is much superior in many ways.

Washington, D. C. T. B. MUNROE.

The Electrochemical Industries and Hydro-Electric Power on the Pacific Coast

To the Editor of Metallurgical & Chemical Engineering

Sir: The legitimate complaints of the electrochemical industries of Niagara Falls of a dearth of power, due to a seemingly short-sighted policy as to water diversion of the Niagara River, might perhaps be somewhat tempered if these industries fully realized that in other parts of the United States there is available power—not potential power in the shape of water seeking a lower level, but actually developed electric power standing idle due to lack of demand for same.

The West has always been considered a breeding-place for optimists; and with true Western optimism some of the hydro-electric power plants have been over-built. They were installed with turbines and generators capable of producing power considerably beyond what seemed the immediate demands, with the hope that by the time the installations were finished there would be a demand for all the power. Such optimism has not always been rewarded, and to-day on this account there are available at various points on the Pacific coast close to 50,000 hp. on the switchboards. This power is obtainable at a price that should make many of the present power consumers in the East envious. The power is there—it is only a question of turning the water onto the wheels. J. W. BECKMAN.

Beckman & Linden Engineering Corp., San Francisco, Cal.

Air Drying

To the Editor of Metallurgical & Chemical Engineering

Sir:—In my article on "Air Drying," in your issue of Feb. 15, in the last line on page 188, the boiling temperature of ammonia should be —33.7 deg. C. instead of —3.7 deg. C. It is an evident typographical error, as the temperature is given correctly in Fahrenheit degrees.

Philadelphia, Pa. CARL HERING.

More About the Rat Problem

I.

To the Editor of Metallurgical & Chemical Engineering

Sir: I read in your paper of February 1 what you say about rat skins. I am a young man just starting out in life and I would like very much to go into business for myself. I know where there are a great many rats and if I could get ten cents each for them I could do better than I am doing now, although I have full charge of filing some of the daily reports in an insurance office. I hope you will excuse me for asking the question, but I could not quite make out whether you were in earnest or not, because you sometimes say, "Rats" when you mean a joke. If there is such a factory that tans rat skins will you please let me know, because I would like very much to catch rats and sell the skins for ten cents apiece.

Yours truly,

REGINALD HAROLD SALTASH.

* * *

II.

Women's Work Extension Bureau

To the Editor of Metallurgical & Chemical Engineering

Sir: Please give by return mail full particulars of ratskin leather business lately referred to in your journal. We do not propose that women shall catch,

murder or skin the rats, but we have in mind a group of women who are disposed to take full charge of selling the skins to the tannery provided the skins are not too smelly,

Yours truly,
(Miss) MARTHA L. PEPPERTON,
Corresponding Secretary.

* * *

III.

editor metulgical and chemal engeering

dere sorr i can fornish yo with rat skins i send about 150 or 200 to yo nex month.

yorse truly,

H. HORNER.

* * *

[We shall consider these letters seriatim:

I.—We are pleased with Mr. Saltash's communication because we always like to hear of ambitious young men. At the same time we are distressed to think that he should regard us as being frivolous of mind. No, Reginald, we were wholly in earnest. We do not like rats and we wish the country well rid of them. That is why we entered into conference with the best leather chemist we know and induced him to study the economy of the problem. It is his judgment that the skins would be worth at least ten cents apiece. It was his decision that the industry would be profitable if 5000 skins a day were assured. We are disposed to say that since you are in the insurance business, here is your chance, but you might think we were joking again and this is just what we want to avoid. Being somewhat heavy in build and ruddy in countenance we have constantly to fight against this error, this suspicion, that we are engaged in efforts of mirth the while we are striving to bring forth the truth. We shall not attempt, however to burden you with our secret sorrows. Take it for granted, please, that we never say rats when we mean a joke.

To return to the more familiar subject of assurance or insurance, we shall now repeat that here is your chance. It is the one problem unsolved. The tanneries are in sore straits for lack of hides. The complaint is general of what amounts almost to a leather famine, and lack of hides is the only reason for it. And here, according to the hypothetical census, are a hundred million rats, and every one of them with a hide. It is only a question of catching the rats, "murdering" them, skinning them and then salting or drying the skins—and the rest is easy. All that is required is the mind of a captain of industry and with this the whole problem is as good as solved. Go to it, Reginald Harold Saltash! We believe in you. There is not only wealth in it, but fame. St. Patrick drove the snakes out of Ireland and look at his reputation to this day, a thousand years after his death! The United States is a bigger country than Ireland, and the man that drives the rats out of it will surely be a hero. There'll be big bronze effigies of you, lad, in the public squares, and thousands of little Reginald Saltashes crying glory, hallelujah to the honor of your name, the livelong night. We wish you all success. Then, when you have the matter in hand and are as rich as New Jersey Zinc, we hope you'll call in and pass the time o' day with us. We shall be glad to see you.

II. Our answer to Miss Martha L. Pepperton, corresponding secretary of the Women's Work Extension Bureau, is to refer her to Mr. Reginald Harold Saltash, who is, we understand, giving the matter of ratskin brokerage his serious attention.

III. Mr. H. Horner suffers from the same defect as do his fellow correspondents; he does not read carefully. We never offered to buy ratskins and we enter here a flat contradition of one of his statements: He shall not send us about 150 or 200 next month. That is, he may send them, but they will not reach us. The head porter has instructions to smell carefully every package that is delivered, and if at any time he smells 150 or 200 rats or parts thereof, within the parcel, he is to forward it straightway back to H. Horner or to the Dead Letter Office.

We do not want to shirk our duty, but we think we have done our share in connection with the rat problem.]

Coming Meetings and Events

American Chemical Society, spring meeting, Kansas City, Mo., week of April 9, 1917.

American Electrochemical Society, spring meeting, Detroit, Mich., May 2-5, 1917.

American Iron and Steel Institute, New York, May 25-26, 1917.

American Society for Testing Materials, Atlantic City, June 26-30, 1917.

Third National Exposition of Chemical Industries, Grand Central Palace, New York, week of Sept. 24, 1917.

American Institute of Metals and Foundrymen's Association, Boston, week of Sept. 24, 1917.

American Electrochemical Society, autumn meeting, Pittsburgh, Oct. 3-6, 1917.

American Institute of Mining Engineers, annual meeting, St. Louis, Oct. 8-13, 1917.

Nitro-Starch as an Explosive

By S. S. Sadtler

High explosives, like many other things, are of great importance for the operations of war and the pursuits of peace. The manufacture of high explosives, however, has grown very greatly in this country during times of peace alone, and the development of the manufacture of commercial high explosives which took place before the present war is likely to be distanced after the war. This forecast is based on the new avenues that had been barely laid out just before the upheaval.

High explosives for commercial uses (mining, blasting, etc.) and excluding all applications for use in ammunition such as smokeless powders, have had a rapid development in recent years. The United States Government bulletins show that while in 1890 but 30,626,738 lb. of all grades of high explosives were used for such commercial purposes, 85,546,456 lb. were so used in 1900, 130,920,829 lb. in 1905, 204,763,299 lb. in 1910, and 244,151,789 lb. were so used in 1915, while nearly 15,000,000 lb. were exported.

Of the 1910 amount, 9,607,488 lb., and of the 1915 amount, 25,697,818 lb., are what is called "Permissible Explosives," specially prepared for use in coal mines. This class of products was practically unknown prior to 1902, in which year but 11,300 lb. were used. These permissible explosives are rapidly supplanting the use of black blasting powder in a large field, as the following statistics clearly indicate: Black blasting powder used in 1913, 229,939,525 lb.; 1914, 206,099,700 lb.; 1915, 197,722,300 lb. It should be noted, however, in this connection that the coal production was the largest of any year in 1913.

This rapid growth of the use of commercial high explosives was, however, in the well-known and established field of mining and quarrying, but an additional field is now being very rapidly opened for them and

the uses here are capable of almost unlimited development. This field is the application of high explosives in land tillage, tree planting, and a wide range of agricultural applications, all of very recent development. In 1914 nearly 30,000,000 lb. were used in this field, and as yet only a small portion of the farming element really know of these possibilities, and a still smaller number use them. However, the growth in this direction has been very rapid and the amounts to be utilized a few years hence, when the benefits are fully made known by the agricultural journals and the Government bulletins will be enormous. This is appreciated by the explosives manufacturers, and every effort is now being made, especially by the Du Pont Co., to bring it to the attention of the agricultural community by means of illustrated booklets and circulars. The United States Department of Agriculture is also sending out many Farmers' Bulletins devoted to disseminating knowledge on this subject.

The application of high explosives to mining and general commercial purposes may be said to date from the discovery of Nobel that nitro-glycerine could be mechanically absorbed in kieselguhr and then handled with a sufficient degree of safety to warrant its use. The product was called dynamite, but this name now applies broadly not only to nitro-glycerine absorbed by other inert materials like sawdust, mica-powder, etc., and to mixtures of the same with yet other ingredients both inert and active (the latter may be combustible like sawdust or oxygen furnishing, like nitrates), but it also applies to various high explosives containing no nitro-glycerine. The different strengths of high explosives, 20, 25, 30, 35, 40, 45, 50 per cent and up, are measured by the amount of nitro-glycerine there would be in a straight nitro-glycerine dynamite of equal strength.

At present there are an infinite number of chemical mixtures aiming to meet the different working conditions. By the solution of gun-cotton or nitrocellulose in nitro-glycerine (in which it readily dissolves, forming a jelly-like mass), we obtain blasting-gelatine, gelatine-dynamites, indeed other ingredients may be and are admixed. Low-freezing dynamites are also obtained by the addition of the allied liquid nitro-derivatives. Gun-cotton (or the higher cellulose nitrate) has not been found to be applicable by itself for the field of commercial blasting and mining explosives, except for submarine blasting where the compressed gun-cotton finds a use, as it is too bulky in comparison to its weight for other work.

The ideal high explosive should have the following qualities:

First—It should be of great strength and capable of reduction and also of speed regulation.

Second—It should be safe to make, transport and use.

Third—It should be compact, while plasticity is also very desirable in some cases.

Fourth—It should be unaffected by low temperatures.

Fifth—It should keep well without deterioration.

Sixth—It should emit no dangerous or noxious fumes and should be smokeless after firing.

Seventh—It should be low in cost.

Eighth—It should be waterproof.

I am now coming to my subject. Heretofore the chief substance for commercial high explosives has been nitro-glycerine, but there are serious inherent drawbacks to its use and, for some time, beginning even before the European war, the price has been mounting. This was due to the greater growth of demand for glycerine than the increase in supply.

For some time there has been an earnest effort put forth to find a satisfactory substitute for nitro-glycerine

dynamite, but without real success until recently, when great improvements in the manufacture of nitro-starch and the invention of a suitable container for the use of nitro-starch explosives, for commercial mining and blasting, has, it seems to the writer, placed nitro-starch where it is now capable of replacing nitro-glycerine explosives almost entirely for commercial purposes such as mentioned above.

Starch, which has an analogous chemical composition to cellulose and forms corresponding nitrate esters, was early suggested as the basis of a high explosive, having all the advantages of cotton without either its bulk, or higher cost. Marshall in his work on explosives says, however (page 173): "In spite of the cheapness of the raw material, starch, it (nitro-starch) has never been able to displace nitro-cotton; this is partly due to the instability of nitro-starch and partly to the mechanical difficulies in nitrating and purifying it." Similarly, Escales, a well-known German authority on explosives, says in his work "Die Schiessbaumwolle," 1905 (page 273): "Nitro-starch has so far found but little practical application; the reason for this is to be found in the insufficient stability, in particular of the high nitrated products, and above all in addition, the great hygroscopicity of nitro-starches." Marshall, however, records the production of a relatively stable nitro-starch with 14.04 per cent N, but says after describing the process for its manufacture, "Such a process is of course quite unsuitable for use on a commercial scale, but it seems to indicate that nitro-starch itself is fairly stable if it can be separated from impurities." These impurities from the standpoint of nitration, are natural to the starch.

There are impurities in even the best commercial starch. I have been chiefly concerned with the use of maize or corn-starch, and the impurities to be considered are moisture, nitrogenous substances, fatty acids, phosphates, and probably lecithins which may account for the presence of more or less of the fatty acids, phosphates and nitrogenous substances present in starch. Of course there is an envelope of cellulose around the starch substance, but for purposes of nitration this presents no drawback. The starch substance itself is probably complex physically and molecularly, but essentially it is either $(C_6H_{10}O_5)_n + H_2O$ or $(C_6H_{10}O_5)_n$, where n represents a large integer in either case, and different values of n may account for what grounds there are for the belief in the complexity of the starch substance. The starch substance itself is certainly colloidal and the problem must be attacked along these lines.

With regard to the amount of nitration, there have been various hypotheses made as to what is possible. Hough (U. S. Patents 751,076 and 790,840) claimed as high as 16.5, but if this amount of nitrogen can be fastened to the carbohydrate nucleus, it is in too unstable a condition to be of any practical importance and I am inclined to believe that a tri-nitrate $(C_6H_7(NO_2)_3O_5)$ with 14.14 per cent N is the limit of a possible stable nitrate, although its attainment is difficult. In following my process (U. S. Patent 1,211,761) I have never attempted to secure a higher nitration than 13 to 13.3 and do not believe a nitro-starch can be stable with as much nitrogen as would be found in a full tri-nitro-starch, or, if the molecule is taken as $(C_{12}H_{20}O_{10})$ a hexa-nitro-starch. Some of the nitro substitution products are so unstable that they must be decomposed and removed in the processes of purification so that their later decomposition does not cause the decomposition of the main portion of the product. These unstable products are probably higher nitro substitution substances and products of side reactions.

Nitro-starch is an ester or an organic salt of an acid radical and a derivative of the alcohols. Hydrogen of the OH groups of the starch carbohydrate or carbohydrates is substituted by NO_2 groups from nitric acid. Like the esters, decomposition may be effected readily, if indeed it may not be said that there is a tendency to dissociate. Both acids and alkalis are active agents in causing decomposition. The rapidity of decomposition with acids is a function of the time, quantity and temperature for any particular acid or alkali. Now, there is no stronger acid than nitric; in other words, no more highly ionized acid, and sulphuric is nearly as strong. Therefore, as the nitration is effected by nitric acid rendered anhydrous by strong sulphuric, traces of nitric and sulphuric acids must be as near completely removed as possible. It might seem to the uninitiated as if this were quite easy, but due to the dense colloidal character of nitro-starch this is quite difficult to effect. Nitro-starch is very much denser than nitro-cellulose, as a given weight of the former occupies a very much less space than nitro-cellulose even when the latter is under great pressure.

Nitro-starch by my patented commercial process with 13 to 13.5 per cent nitrogen—1 lb. dry starch—produces 1½ lb. Nitro-starch, S. G. 1.57, Abel Test 175 deg. F. 30′. Sy. Stability test at 165 deg. C. 1′ 35″. Combustion test 182 deg. C. At 135 deg. not exploded in 30′. KI and Starch test 65 minutes at 70 deg. C.

Nitro-starch is insoluble in water, even in boiling water, wherein it differs from corn starch. It also differs from corn starch in being soluble in some organic solvents such as acetone and amyl acetate. The structure is unchanged in nitration although the grains are somewhat swollen. The color is practically unchanged if the nitration is properly carried out and the water available is satisfactory. Nitro-starch is very analogous to nitro-cellulose. It, however, is much denser. In ordinary condition it only occupies about one-fifth the volume of nitro-cellulose. This is before treatment with organic solvents. When treated with solvents for the purpose of colloiding, which solvents are afterwards evaporated, it has about the same bulk as nitro-cellulose in its colloided form, but differs from it quite markedly in its properties, as it does not form as tough a colloid as nitro-cellulose.

For blasting this material has a great many advantages, although some prejudice might have to be overcome in some cases. It is in the first place safe, due to the fact that it cannot be accidentally exploded except by exploding a cap in contact with it. It gives off no bad fumes in mining tunnels when reasonably well compounded. The fumes, under no circumstances, produce headaches, and have seen men go right into the tunnels after firing it, although, of course, this is not advisable. In mining use it is known for its quick and short flame. It is non-freezing.

At a higher temperature, 79.4 deg. C., the results in a few cases were as follows:

Nitrogen Contents.   Stabilities.
13.55 per cent......Abel Test at 79.4 deg. C. 25 min.
13.14 per cent......Abel Test at 79.4 deg. C. 30 min.
13.00 per cent......Abel Test at 79.4 deg. C. 32 min.

A quantity made over ten months previously showing no deterioration from its original stability.

This nitro-starch stands the International test for 48 hours at 75 deg. C. with a loss of 0.5 per cent in weight and no red fumes. Better results than any here given have been found where the product had exceptional washing.

A sample that stood the Abel test at 79.4 deg. C. for 20 minutes was then subjected to the International Test for 48 hours at 75 deg. C. with no apparent loss of N.

This sample was then again subjected to the Abel Test at 79.4 deg. C. for 18 minutes before the slightest sign of discoloration appeared on the starch paper.

Nitro-starch differs from nitro-cellulose in its density. The real specific gravity is 1.55 to 1.60, but its apparent specific gravity is what really counts as it is naturally so dense that it can easily and cheaply be compacted for use in cartridges for rock blasting which cannot be done very well with nitro-cellulose.

One important property of nitro-starch is that it takes so little solvent to dissolve it (sometimes called colloiding). This militates against it for use in lacquers, but in making plastics for wet rock blasting it is greatly to its advantage. To make a gelatine dynamite with nitro-cellulose it requires about 5 to 6 per cent nitro-cellulose to make a pasty mass, and about 80 to 85 of nitro-starch. As nitro-starch is cheaper than and yet as powerful as nitro-glycerine, while nitro-cellulose is more expensive, it can readily be seen how desirable nitro-starch is for this work.

Quite a little has been said about the hydroscopic character of nitro-starch. I can only say that what I have produced by my process would not be considered hydroscopic. All fine powders will attract some moisture, generally measured in tenths of a per cent, and nitro-starch does not do more. Several times I have found some that had been freely exposed indoors in summer and winter to have from 0.2 to 0.3 per cent moisture. Personally I would not expect it to be hydroscopic as it has organic solvents for its solutes and not water. A condensed comparison of nitro-starch and nitro-glycerine may be given as follows:

DYNAMITE	NITRO-STARCH
A. *Disadvantages:*	A. *Disadvantages:*
Dangerous to shock.	Not plastic in natural state although can be made plastic if desired.
Highly injurious fumes, causing headache and sickness.	More bulk than dynamite unless artificially compressed.
More or less sensitive to changes in temperature, according to grade and composition, most grades easily freezing in cold weather.	Rendered temporarily inert when in powder state by wetting.
Cost: High at present and likely to remain high as compared with previous prices, even after the war.	

DYNAMITE	NITRO-STARCH
B. *Advantages:*	B. *Advantages:*
Compact.	Not in any way sensitive to shock, or in fact cannot be exploded in any other way than with a fulminate detonating cap. Even fire will not explode it.
Plastic.	May have good stability.
Effective because many years of experimentation have given it adaptability.	Effective when properly prepared for a wide range of usefulness, possibly as great as that of nitro-glycerine powders.
Non-hydroscopic and little affected by wet situations.	Does not have injurious fumes.
Good stability.	Its lightness when not specially compacted is advantageous for many purposes.
	Is not sensitive in any way to changes of temperature.
	Is non-hygroscopic.
	Will undoubtedly be the cheapest organic-explosive.

One of the chief points of merit in the use of nitro-starch is its cost. It can readily be seen that if there is no special difficulty in the manufacture, and there is none, that its being made from a base costing 2⅛ to 2¼ cents a pound, as compared with glycerine at 30 to 60 cents a pound, or cellulose rising of 10 cents, that

there is great economy in its use. We can say that we not only feel that it is as easily manufactured as nitro-cellulose when the cost of the bases is not considered, but that for reasons of simplicity in handling and time of nitration, it is more economically manufactured than nitro-cellulose.

The field of commercial high explosives or blasting powders is so much greater than that of ordnance in normal times that it is hardly necessary to consider them in looking up this new line of manufacture. We might say, however, besides its use for blasting that it seems to offer special advantages for torpedoes for under-water or aerial use. This is due to its compactness and high explosive power. For such uses or for grenades it would have to be detonated by fulminated mercury, as there is no other way that we know of for exploding it. Shock alone will not do it, nor will fire alone do it.

The writers associates patented an expanding waterproof cartridge which greatly adds to the improvements in nitro-starch alone. The cartridges ordinarily used for high and permissable explosives are of paraffined paper made into cylinders (of the diameter required), either wrapping straight or spirally with the ends either turned in roughly and dipped in paraffine, or where made by the latest devices the ends are crimped in (similar to a shot-gun cartridge) and also dipped in paraffine. In the use of these paper cartridges, say for drill holes, it is customary to have them of the same diameter as the steel drill head so that they will not stick and can be loaded right back to the ends of the holes, for the torque of the drill-iron in drilling the holes, considerably enlarges its diameter, a 1" drill making a 1¼" hole. It is thought absolutely necessary to have the diameter of the hole completely filled with the explosive to be used in order to fully utilize the strength of the explosive. Therefore it is customary to slit the paraffine paper cartridges lengthwise two or three times with a knife, insert slit cartridge in the hole, sliding it back with a wooden tamping rod till it grounds on the end of the hole and pressing it till it opens up, shortens, and more nearly fills the hole (but exposes its contents). Others where required are introduced in like manner except the last which is not slit, but the detonator inserted and tied in, slid up to the last cartridge and then tamped. The serious disadvantages encountered are that it is somewhat dangerous to slit most explosives with a knife, it exposes the contents to any dampness and in the case of non-plastic explosives in rising holes prevents their use, and in the case of both plastic and non-plastic explosives is liable where there are fissures in the rocks to cause a leakage where it may later be the cause of an accident. In ascending holes (raises) if one should slit an ordinary nitro-starch cartridge and try to tamp

it into place (push it up the drill-holes as far as possible and then some) a good deal of the powder will rain out on the miner.

Most cartridges must not be slit in wet holes, but we have produced a cartridge remedying these difficulties, the patent for which has just been allowed for the United States. It consists of an inner paraffined paper container that can be expanded when in place in the hole, completely filling it without slitting and exposing the contents, and is waterproof, and an outer container to keep it in shape in transportation and handling, to be very quickly removed without the use of a knife when the cartridge is to be used. This cartridge, inner and outer containers complete weighs 1/5 of an ounce as against ½ ounce for the cartridge now on the market, and with the outer container removed ready to fire .16-1/3 of an ounce. It is desirable to load drill holes with explosives not paper, for paper represents loss of power, loss of oxygen and added smoke. This cartridge should cost little more than that now in use.

We feel that with the properties of nitro-starch in mind, one can form some idea of the military and naval uses therefor. We can only give our prediction of the future of nitro-starch.

We know that nitro-starch has a great field in both military and naval use, being preferable to gun-cotton wherever it is used uncolloided for the following reasons: greatly increased weight per bulk (admitting of larger charges in mines, torpedoes, hand-bombs, grenades, etc.), greater stability, less liability to spontaneous combustion, and great reduction in cost. It is very much cheaper than tri-nitrotoluol.

We believe from the crude tests to which we have been enabled to subject nitro-starch that it will stand being fired from large guns as the exploding contents of explosive projectiles if componded slightly. Under the proper conditions this could be quickly ascertained.

In conclusion I would say that nitro-starch will make satisfactory forms of the many commercial explosives desired to be manufactured on a large scale and sold for what it is. "nitro-starch explosive." For military purposes it will be found useful, as it may be readily made stable without the addition of dope, and it is compact, powerful and cheaply made.

Philadelphia, Pa.

Industrial Activity Along a Southern Railroad

For the adjoining illustrations showing a number of industrial plants along the Carolina, Clinchfield & Ohio Railroad we are indebted to Mr. Charles F. Roth, one of the managers of the annual chemical exposition in New York, who took these photographs during a recent visit to the South.

FEDERAL DYESTUFF AND CHEMICAL COMPANY, KINGSPORT, TENN.

SOUTHERN POTTERIES, INC., ERWIN, TENN.

KINGSPORT EXTRACT CORPORATION, KINGSPORT, TENN.

KINGSPORT, TENN., CLINCHFIELD PORTLAND CEMENT COR-
PORATION, KINGSPORT PULP CORPORATION
IN BACKGROUND

That a railroad builds up a country, is an old story. But the results which the Carolina, Clinchfield & Ohio Railroad has attained in the last few years in building up new industries with marvelous rapidity, are unprecedented at least in the South. And absolutely novel anywhere is the extent to which the advice and help of the chemical engineer has been sought in this work by the progressive president of the road, Mr. Mark W. Potter, resulting in the creation of a growing industrial center with a certain chemical individuality.

The road operates in five States from Elkhorn City, Ky., to Spartanburg, S. C.

Erwin, Tenn., the division point of the line, is one of the centers of activity. There are at this place the Southern Potteries, Inc. (Southland and Dixie being two important brands of fine tableware of their make), the Clinchfield Products Corporation (mining feldspar), an automobile spoke factory, and a silk mill of A. P. Villa & Co. The Holston Corporation which has large holdings in the city is laying out a city beautiful through Grosvenor Atterbury of New York.

Kingsport, Tenn., is another very lively new industrial center. There is the Clinchfield Portland Cement Corporation with a monthly output of 100,000 barrels. A lime plant has just been built by Mr. R. K. Meade, of Baltimore, to make lime for this company and shortly it is expected to burn dolomite to be converted into lime and magnesium carbonate and possibly magnesia at the Federal Dyestuff & Chemical Company's plant.

Lime will also be supplied to the Kingsport Tanning Corporation which co-operates with the Kingsport Extract Corporation, making 25 tons per day of tanning extract. The daily output of the tanning company is 100 hides.

The Kingsport Pulp Corporation is to use the spent chips and wood shavings from the Extract Corporation and make them into paper pulp by the soda process, and paper is made by the Kingsport Paper Corporation.
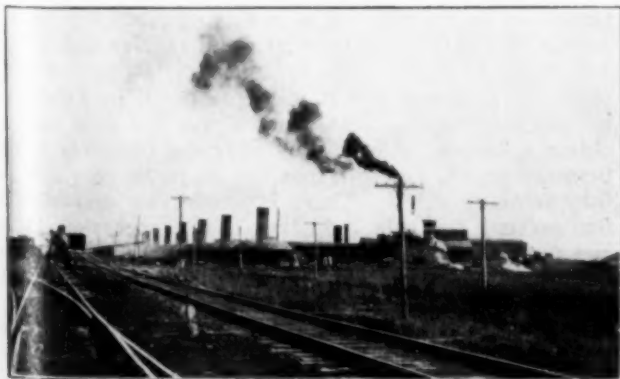
KINGSPORT BRICK CORPORATION, KINGSPORT, TENN.

The Kingsport Brick Corporation has 28 kilns, with a daily output of 130,000 brick. Sewer pipe is soon to be another of their products.

The Federal Dyestuff & Chemical Company, the product of the genius of Dr. John C. Hebden, has been in operation since January, 1916, and is now producing forty different dyes.

The DeCamp Glass Casket Company will shortly start operation at Kingsport, using fine glass sands from the local hills.

Coal comes for the various industries on the Carolina, Clinchfield & Ohio R. R. from Clinchfield, Va. The dye plant is getting salt for manufacture of caustic soda and chlorine from C. C. & O. property, and so on.

This whole industrial activity has already developed many of the district's natural resources, though more remains to be done. The fact that the Kingsport valley industries are almost self-contained is one of the noteworthy economical features of the whole development.

Properties of Metals and Alloys

The Bureau of Standards is undertaking very useful work in a systematic endeavor to collect the most reliable information available on the properties of metals and alloys.

As an illustration of the information wanted the following list of the properties of copper is given, but criticism of the constants for copper is desired.

Name of metal or alloy:		Commercial electrolytic copper		
State or condition	Cast	Annealed	Hard Drawn	Remarks
Chemical composition and impurities	99.90% Cu, 0.08% O_2, 0.002% Pb, 0.0005% As, 0.002% Ag, 0.003% Fe			
Density, g. per cm.^{3}	8.89			
Shrinkage coefficient, %	1.42			
Tensile strength, lbs. sq. in	20–30,000	30–40,000	40–60,000	Ranges of commercial variations
Yield point, lbs./sq. in				
Elastic limit, lbs./sq. in				
Elongation in 2", %		30–50	40–60	4–5
Reduction of area, %		30–50	40–60	
Brinell hardness, H. N	30–40	30–40	80–100	
Scleroscope hardness			6–7	22–24
Behavior in compression	Yields indefinitely and flattens out			
Frictional coeff. (steel)				
Abrasion resistance				
Melting range, °C. or °F.	1083.0°C.			
Coeff. of expansion, per °C	0.00001666			
Specific heat, cal. per g. degree	0.0917 (25°C.) Sp.h. = .01917 + .000048 (t − 25)			
Thermal conductivity	3.73 ($\frac{\text{watt seconds}}{\text{cm − second − degree C}}$)			
Electrical conductivity, ohms (meter, gram)	30–90%	100% = 0.15328	96–97%	
Temp. resistance coeff. per degree C	0.0000393			
Resistance to corrosion				
Hydraulic properties				
Optical properties, emissivity for λ = .65μ	For liquid (1100°C.) = .150 For solid (1080°C.) = .117			
Miscellaneous (including any other known property)				

Analogous information is desired on other metals and alloys and it is hoped that this collection of data will render generally available the most acceptable values of such constants and may also serve as a basis for further experimental investigation. In each case the numerical values should be representative of and fair to the material for technical practice, rather than special values, as for instance the highest tensile strength, etc., that may be obtained.

Other points which are to be taken into account in the compilation of these data are as follows:

The chemical composition should be known to apply strictly to the alloy for which properties are given.

The state of the metal as cast, annealed, forged, rolled, etc., should be given in as great detail as possible.

The authority or source for all numerical values should be given.

The limits or tolerances which should be allowed or expected in practice for any constant should be given.

When possible and known, the variation with temperature of any property should also be given.

Data on the effect of impurities on any of the physical properties of any metal or alloy are important.

Some of the alloys for which data are desired are the following: Aluminium and its light alloys with zinc, copper, etc., of stated percentages; nickel, Monel metal, and copper-nickel alloys; aluminium bronzes, such as Al7 — Cu93, Al10 — Cu90, etc.; manganese bronzes, cast and wrought; phosphor-bronzes, such as Cu80,. Sn12, Pb7, P1, etc.; Muntz metal, naval brass, Tobin bronze, and brass of 60Cu — 40Zn; yellow brass of 70Cu — 30Zn, the red brasses and other brasses; bronzes of 90Cu — 10Sn, 88Cu — 10Sn — 2Zn, 88Cu — 8Sn — 4Zn, and their modifications with Pb and Fe added, etc.; bearing metals; white metals, etc.

Waterpower Decison of U. S. Supreme Court

The recent decision of the U. S. Supreme Court in the case of the Government versus the Utah Power & Light Company is noteworthy as it settles a principle of great importance to all states having public lands the development of which has been retarded by uncertainty as to the interpretation of federal laws. The question in doubt has been whether the congressional act of 1866, giving rights-of-way over government land for the use of water for beneficial purposes has been repealed by later acts of Congress by which the use of rights-of-way over government land is restricted to revocable liens and easements issued by the Department of Interior or Agriculture. This question is answered in the affirmative by the present U. S. Supreme Court decision in favor of the Government.

From this decision which was written by Justice Van Devanter, we quote the following:

"We are concerned here with three suits by the United States to enjoin the continued occupancy and use, without its permission, of certain of its lands in forest reservations in Utah as sites for works employed in generating and distributing electric power and to secure compensation for such occupancy and use in the past. The reservations were created by executive orders and proclamations with the express sanction of Congress. Almost all the lands therein belong to the United States and before the reservations were created were public lands subject to disposal and acquisition under the general land laws. The works in question consist of diversion dams, reservoirs, pipe lines, power houses, transmission lines and some subsidiary structures." . . .

"In occupying and using the government lands as sites for these works the defendants have proceeded upon the assumption that they were entitled so to do without seeking or securing any grant or license from the Secretary of the Interior or the Secretary of Agriculture under the legislation of Congress, and, in truth, they have neither applied for nor received such a grant or license from either. But, notwithstanding this, they assert that they have acquired and are invested with rights to occupy and use permanently, for the purposes indicated, the government lands upon which the works are located." . . .

"The first position taken by the defendants is that their claims must be tested by the laws of the State in which the lands are situated rather than by the legislation of Congress." . . . But "state laws, including those relating to the exercise of the power of eminent domain, have no bearing upon a controversy such as is here presented, save as they may have been adopted or made applicable by Congress."

"The next position taken by the defendants is that their claims are amply sustained by Nos. 2339 and 2340 of the Revised Statutes, originally enacted in 1866 and 1870. By them the right of way over the public lands was granted for ditches, canals and reservoirs used in diverting, storing, and carrying water for 'mining, agricultural, manufacturing and other purposes.' The extent of the right-of-way in point of width or area was not stated and the grant was noticeably free from conditions. No application to an administrative officer was contemplated, no consent or approval by such an officer was required, and no direction was given for noting the right-of-way upon any record. Obviously this legislation was primitive. At that time works for generating and distributing electric power were unknown and so were not in the mind of Congress. Afterwards when they came into use it was found that this legislation was at best poorly adapted to their needs. It was limited to ditches, canals and reservoirs, and did not cover power houses, transmission lines, or the necessary subsidiary structures. In that situation Congress passed the Act of May 14, 1896, c. 179, 29, Stat. 120, which related exclusively to rights of way for electric power purposes and read as follows:

" 'That the Secretary of the Interior be and he hereby is authorized and empowered under general regulations to be fixed by him, to permit the use of right of way to the extent of 25 ft., together with the use of necessary ground, not exceeding forty acres, upon the public lands and forest reservations of the United States, by any citizen or association of citizens of the United States, for the purposes of generating, manufacturing, or distributing electric power.'

"We regard it as plain that this act superseded Nos. 2339 and 2340 in so far as they were applicable to such rights of way."

Alcohol from Calcium Carbide.—Works for the manufacture of alcohol from calcium carbide are contemplated in Switzerland at a cost of 9,000,000 francs (about $2,250,000). The works will require one and a half years to finish. The Lonza Electric Company applied for a license and it was considered in February by the Bundesrat. This concern was the only one to obtain a license. Alcohol for industrial purposes is the primary object, but it is possible to make this alcohol into drinking spirit. There is ample raw material in Switzerland for this industry. The concession is to run for a definite period, and during a certain time no alcohol may be exported. On that account storing facilities must be provided. About 55,000 to 60,000 meterzentner (1 meterzentner = 100 kg.) of alcohol for burning purposes have been required annually in Switzerland. The works will be erected at Visv and will constitute a large new industry.

NEW CHEMISTRY BUILDING, UNIVERSITY OF CINCINNATI

Metallurgy and Electrochemistry at the University of Cincinnati

Ernest Edgar Thum,
Assistant Professor of Metallurgy

AND

Albert Watson Davison,
Assistant Professor of Physical Chemistry

The completion of the new Chemistry Building at the University of Cincinnati prompts a description of the activities of the electrochemical and metallurgical departments in this institution. As a matter of course the chemistry department serves the various other departments of the university in offering the usual subjects in elementary and advanced chemistry to students in the liberal arts, medical and other colleges. A large amount of the equipment of the new building is therefore utilized by such classes; it differs somewhat from that in other institutions of like grade, but since it will be described elsewhere in considerable detail, it need not be discussed here.

The equipment installed to care for the needs of electrochemistry and electrometallurgy is unusually complete, however, and deserves more or less detailed description. Not only will the new building offer unusual advantages for the instruction of chemical and metallurgical subjects, but the manner of teaching them to students of the engineering professions is unique and worthy of description, even at the risk of repeating what has already appeared elsewhere.

Ten years ago the Dean of the Engineering College, Herman Schneider, started his "co-operative course" for engineers. In the intervening years it has passed through the formative stages, weathered the storms of financial panic, business depression and labor troubles, and to-day stands as a pronounced success, favorably noticed on every side. The Engineering College still offers the usual four-year courses leading to the degree of Bachelor of Science in chemical, civil, electical, mechanical or metallurgical engineering, very similar in form and substance to corresponding courses given elsewhere. Of the 500 students registered in the Engineering College during the present academic year, however, 478 are pursuing the "co-operative" course, continuing through five years of eleven months, and leading to the degree of Chemical Engineer, Civil Engineer, Electrical Engineer, Mechanical Engineer or Metallurgical Engineer.

A student desirous of entering a co-operative engineering course and who has satisfied the entrance requirements, presents himself at the university three months before the beginning of his freshman year. After an interview with the head of the course he is electing he is taken to some industrial plant which offers apprentice openings (with apprentice wages) nearest fitted to his capabilities. As an instance a metallurgical engineer may be cutting sand in a foundry, a chemical engineer may be trucking materials in a warehouse, a civil engineer may be working on a railroad section gang, etc.—in general, the work will be in his line, and as severe as he is physically capable of performing. Here he spends the three months intervening until the opening of his first school term, and during this time he must perform the duties of his job in a satisfactory manner in order to earn the right to matriculate. It is obvious that young men deficient in stamina will drop out of sight during this period—in fact, co-operative students seldom become in arrears in their shop work or are reported by their foremen as being unsatisfactory. Indeed, our pedagogical problems would be exceedingly simplified could we discover such a reliable, short-time test for determining their future *scholastic* capabilities.

At the beginning of school two metallurgical students are paired as "alternates" and assigned to some job, taking turns in the shop and in school, changing places each two weeks. In this way the employer has a workman continuously, while the school instruction is repeated for the benefit of the two sections of the class. The alternation between shop and school continues throughout the entire five years, the individual student being changed from one firm to another, and promoted from one job to a better as often as circumstances, expediency and his own ability permit. In general, it is aimed to spend the first year in an iron, steel or brass foundry, the second in a machine shop, the third in forge shops or heat treatment rooms, while the remaining may be spent in various locations in a steel plant, or pursuing some special line of metallurgical or metallographical work with smaller concerns. It is seldom that the student in any of the engineering departments spends the entire five years of his college course in one plant, as few in this vicinity are extensive enough to offer the diversified experience desirable, although the National Cash Register Company of Dayton, Ohio, has worked out some excellent shop courses for co-operative students in their employ, and a large chemical manufacturer of Cincinnati has arranged a five-year course for chemical engineering students, starting as bottle washer and ending as research assistant.

The university profits through the co-operative course in being relieved of the necessity of maintaining the school shops—the practice work in all engineering branches is done by the student working as an employee in a modern industrial organization. The capacity of the school laboratories, drawing and class rooms is doubled, and the necessity of many detailed descriptive courses is eliminated.

The student profits through the co-operative course in being able to earn his living while in school. As a workman in a modern factory he develops industry, loyalty and self reliance. Best of all, he acquires through actual contact that intimate and detailed knowledge of the machines and men he will some day manage.

But for these benefits to accrue to both student and university it is necessary to develop and prosecute a close co-ordination between the theoretical subjects taught in school with the practical objects worked with in the shop. This all-important task is intrusted to a new department called the "Co-ordination Department." The freshmen working in foundries, for instance, meet in class three times a week, and there discuss with the
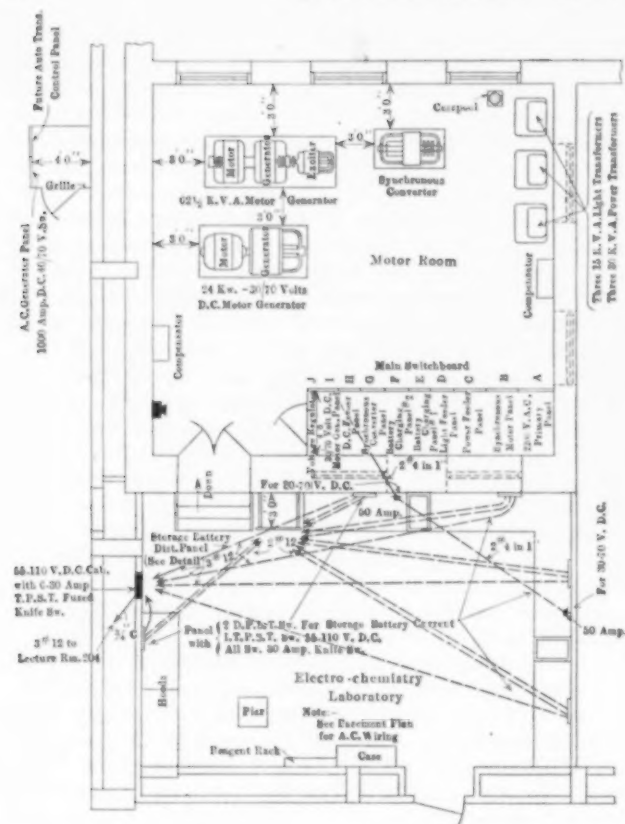
FIG. 1—PLAN OF MOTOR ROOM AND ELECTROCHEMISTRY LABORATORY

FIG. 2—FRONT OF MAIN SWITCHBOARD—DIRECT-CURRENT GENERATOR IN FOREGROUND

instructor in co-ordination various phases of their work. He asks questions of them designed to stimulate their powers of observation, and points out features of their work which have a direct or indirect relation to their theoretical studies. The interchange of information between student and student, and student and instructor serves to make the student a more intelligent, and therefore a more efficient workman, and to emphasize the instructional value of his shop work. As the student's character rounds out in the progress toward graduation, the individuals enter into more and more diverse pursuits, and co-ordination en masse becomes less and less practicable or necessary. But at all times some interested member of the university faculty is in touch with the student's shop work, this instructor visits the plants often enough to be familiar with the undergraduate's work and progress, and he meets his charges once a week in a clearing house for the exchange of engineering information.

The co-operative course, obviously, depends first of all upon the attitude of the employer—the managers of the

co-operating firms. The good will of these men is obtained chiefly because the arrangement is a profitable one for them. Even in his probationary period the co-operative student far excells the usual apprentice; further on in his course he is the equal or better of the mechanic at his elbow; and upon graduation he is available, trained in theory and practice, for the minor executive positions of the staff. In short, it is a step toward furnishing them with efficient employees. Of course, troubles sometimes have to be surmounted, but the net effect upon the employer is a growing realization of the advantages of employing co-operative students—of furnishing them with their "practical" education. Over seventy firms within a radius of fifty miles
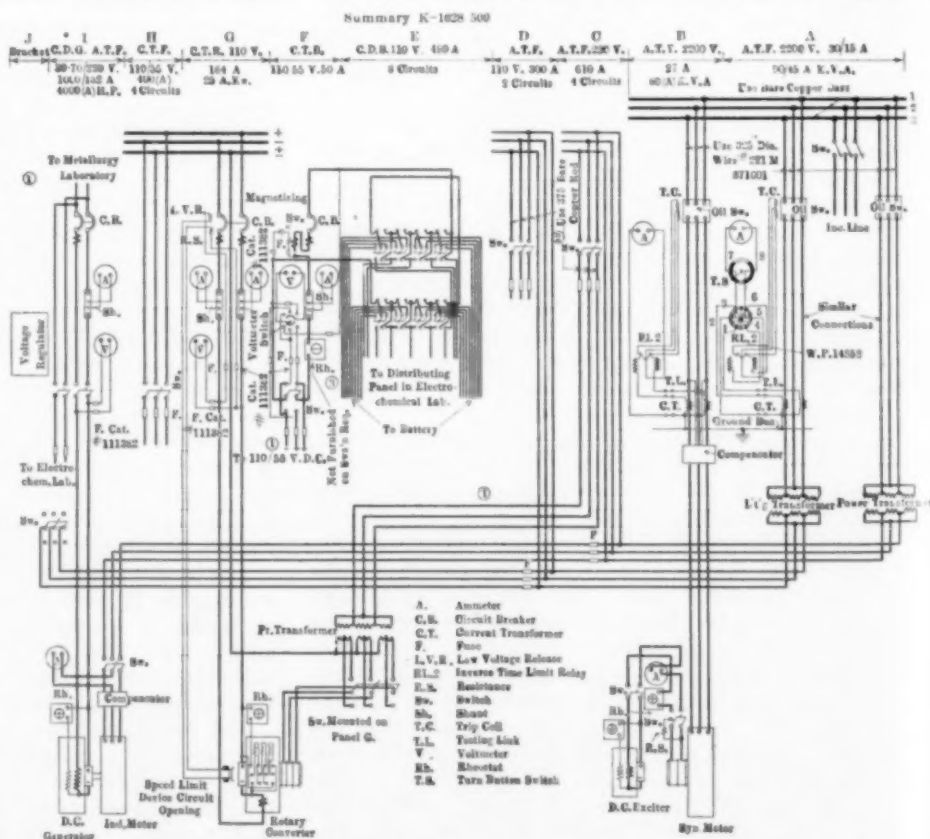
FIG. 3—WIRING ON REAR OF MAIN SWITCH-BOARD
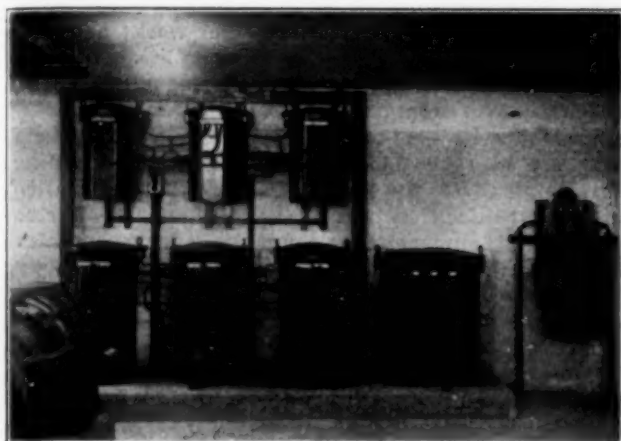
FIG. 4—TRANSFORMER BANK (COMPENSATOR FOR A.C.
GENERATOR ON RIGHT, SYNCHRONOUS
CONVERTER ON LEFT)

of Cincinnati are now employing these undergraduates, and unsolicited requests for more students than we can possibly furnish are continually being received from others.

That there are styles in engineering education like styles in ladies' millinery is possibly a truism. For this reason it is seen that the number of students in a given course will not correspond exactly to the requirements of the nearby industries—nor even approximately in equal measure. Fifteen years ago a high school student who did not aspire to become an electrical engineer was a rara avis, and a co-operative course (should one have existed at that time) would doubtless have been unable to place all the candidates in desirable shops. So it is at present. The isolation of Germany and the interruption of her exports of synthetic chemicals has caused a great agitation in the breasts of innumerable publicists who have forthwith urged upon young America the necessity of studying chemistry. The result is that courses in chemical engineering are very popular—subjects neglected a few years ago have ten to twenty times the number of registrants. Doubtless, in time, metallurgical engineering will feel the effects of some such advertising campaign, and more students will prepare themselves to supply the ever-growing and insistent demand for men who can scientifically control the metallic output of steel works, foundries, forge shops and heat treatment rooms. At present, chemistry has a plethora of students, while the metallurgical department can not supply the positions offered to it.

The co-operative course has caused a very radical alteration in the curriculum, as can be readily seen. For instance, it is unnecessary to describe ordinary molding methods to a man who has worked in a foundry for a year. Again, in the study of open-hearth steel production, we can describe the furnaces best by going to one of our co-operating plants and examining in detail a furnace, shut down for repairs. The chemistry of the process may best be studied by observing a heat from charging to tapping—obtaining weights, observing temperatures, and taking samples for later computation and analysis in classroom and laboratory.

Laboratory work in metallurgy is not eliminated. On the contrary, all engineering students (mechanical, civil and electrical) receive a strong course, covering one semester, in the metallurgy and heat treatment of iron and steel. This course is primarily a co-ordination course, in that it aims to explain the mechanical, physical and electrical properties of the various iron and steel products in common engineering construction by reference to fundamental chemical, physical and metallographical principles. A text is used by the student in home study, which is inclusive enough to contain descriptions of the modern metallurgical and mechanical operations between ore and finished product. The lecture course supplements this and attempts to make definite reference to the metallic materials the young men are handling in their shop work, or will use in later practice. It is remarkable what a variety of requests will come to the instructor to explain in detail some process of shop work. Finally, three afternoons each

FIG. 5—STORAGE BATTERY CHARGING PANELS ON MAIN
SWITCHBOARD

C. D. F. 110 V. 600 A. 30 Circuits

To Distributing Side of D. F. D. T.
Switch on Battery Charging Panel
of Main Switchboard

Switch

F

Plug Switch

Plug Switch

F

Distributing Circuits

FIG. 6—SWITCHBOARD IN ELECTROCHEMICAL LABORATORY

week are spent in the laboratory, where the student makes his own pyrometer, calibrates it, studies a simple equilibrium system, leading up to tests confirmatory of the iron-carbon diagram, which is later utilized in hardening, tempering and annealing studies. From the experimental knowledge thus gained the student makes cold chisels, center punches, malleable castings and casehardened pieces.

Electrochemistry, under the caption Applied Electrochemistry, is taken by students who are candidates for the degrees of chemical or metallurgical engineer. The course aims to familiarize the student with the theory and practice of such processes as deposition and electrolytic refining of metals; alkali chlorine electrolyses; fused bath electrolyses for the preparation of such metals as sodium, calcium, barium, magnesium and aluminium; electrothermic preparation of carborundum, calcium carbide, graphite; the preparation of such alloys as ferrosilicon and ferromanganese; the reduction of phosphorus, and the fixation of nitrogen.

Four lectures are given each week, supported by assignments in Thompson and in Allmand. One hour per week is reserved for quiz work. Twice during the course each student is assigned some electrochemical topic, which will necessitate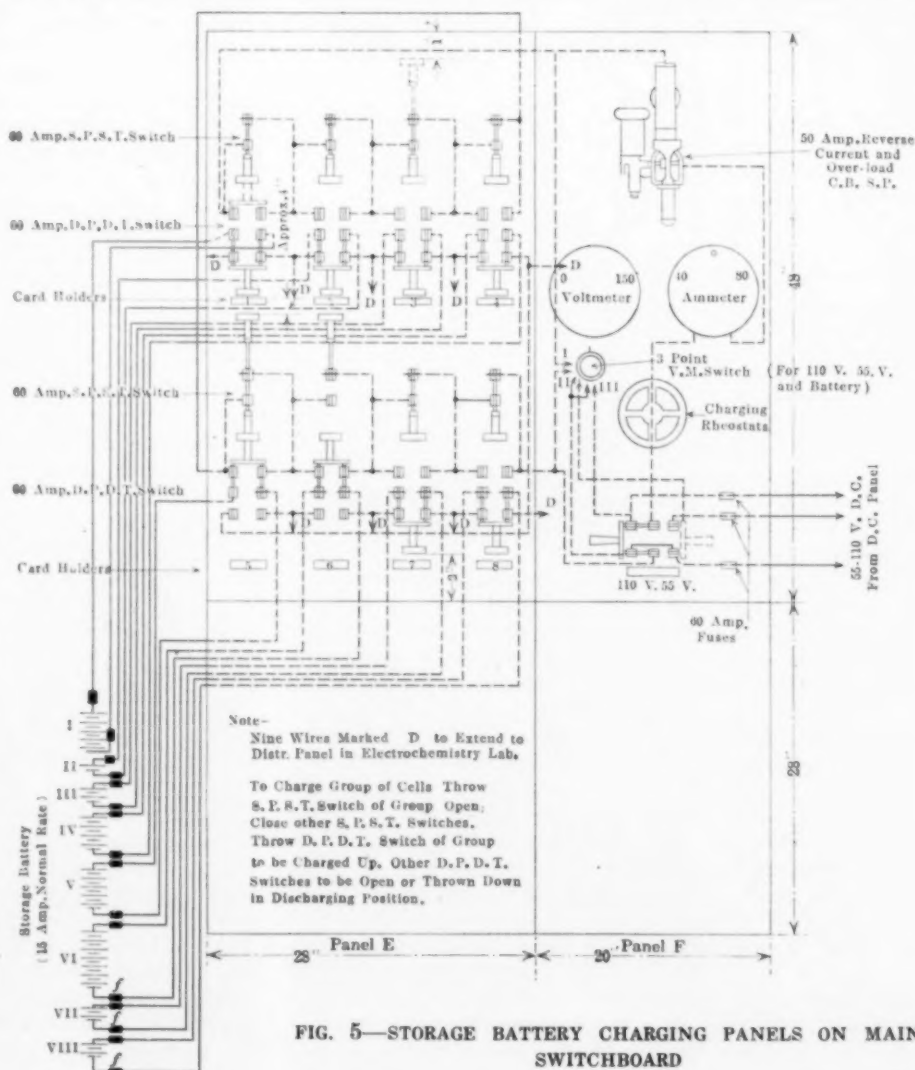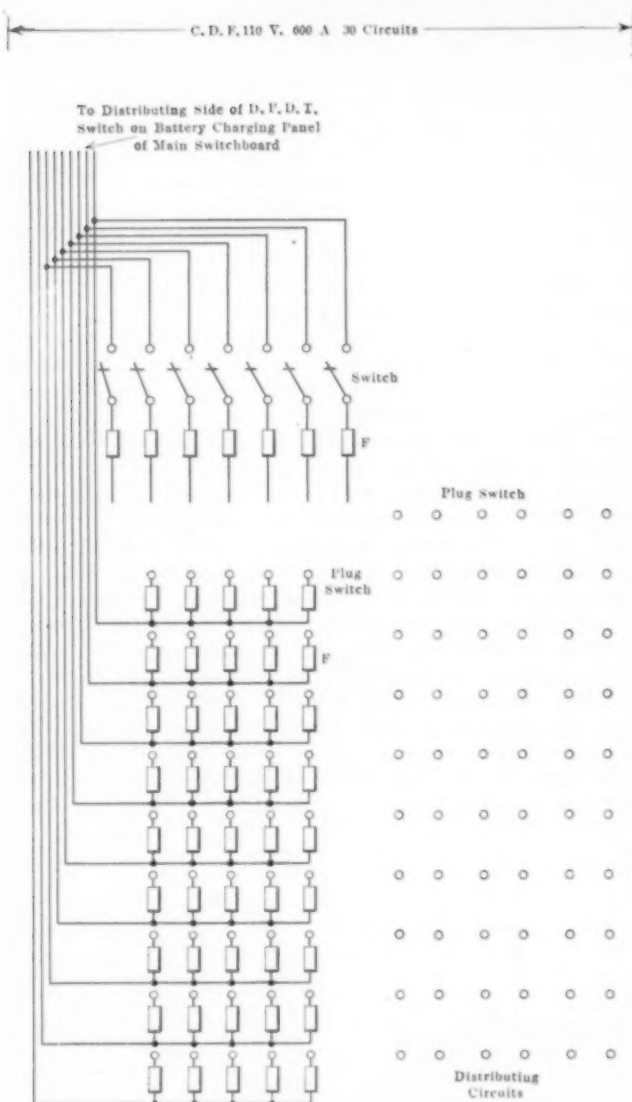 a thorough search of the chemical literature. If a student has chosen an electrochemical problem for his thesis, one of these assignments will closely border on that subject. Laboratory

practice requires three afternoons per week; and since some of the exercises are of a more or less continuous nature, certain experiments may be under uninterrupted observation for from twelve to twenty-four hours.

Students who elect their major work in electrochemistry are also given a thorough theoretical training. This course covers the theory of electrolytic dissociation, migration velocities, transference numbers, electromotive force, single electrode potentials, ionic concentration and overvoltage. Classroom discussion is closely followed in the laboratory practice.

The electrochemical and metallurgical laboratories, situated on the first floor of the new Chemistry Building, each open into the power room, containing the generators and main switchboard (Fig. 1). The electrochemical laboratory is fitted with asbestine stone work tables, with lockers underneath, and with wall panel switchboards containing knife switches and wing binding nuts. Only experiments having small power requirements are performed in this laboratory. In the metallurgical laboratory, beside the usual gas and oil-fired furnaces which occupy the front half of the wing, are to be found the switchboard for electric furnace control, and floor space with a large 12-ft. by 20-ft. hood for electric furnaces.

It is not the aim of the department to maintain "hand-me-down" furnaces of every kind and variety; rather students are expected to construct their own from an abundant stock of electrodes and refractory materials. The plan suggested by Gillett and Lohr, of the Bureau of Mines, of mounting heavy oak platforms on large castors, and building furnaces on these, has been found excellent, as it permits the unit to be moved from place to place. In the case of arc furnaces, it also gives a substantial base for electrode control devices. The metallurgical department keeps ready for use two small arc furnaces, one of the Heroult and the other of the Girod type; and Electrochemistry possesses a 15-kva. vertical Arsem vacuum furnace. These are the only permanent pieces which present plans contemplate. In order to remove furnace fumes so far as possible, the hood above the furnace platform is exhausted directly to the open air by means of a 36-in. fan, driven by a 6-hp. motor. This device, therefore, has no connection with the general laboratory ventilating system.

Fig. 2 shows a view of the front of the main switchboard, while Fig. 3 gives the wiring diagram of the back of the same. In the study of the diagram notice that panel A at the right corresponds to the panel at the extreme left of the photograph.

In describing the generating units, more order will be doubtless brought out of chaos if the authors limit themselves to consideration of one unit at a time. Electrical energy is received from the university power house at 2200 volts, and is transformed in the power room to 110 volts for lighting, and to 220 volts for driving motors. Besides the lighting circuits, each laboratory is generously supplied with 110-volt alternating current for heating devices. Fig. 4 shows the transformer bank for lights, power and furnace work.

Direct current for lantern arcs, storage battery charging and general experimental purposes throughout the building is generated by a 25-kw. synchronous converter shown in the center of Fig. 4. Distribution from this machine is by the three-wire system from panel G; 110 volts being being obtained from one combination of leads, and 55 from either of the other two permutations, 110-volt lines run to all offices, lecture rooms and laboratories, and terminate in polarity receptacles, which are fused for ten amperes. Lanterns are supplied from large slip contact boxes, fused for sixty amperes. In the electro- and physical-chemistry

FIG. 7—SWITCHBOARD FOR ELECTROCHEMICAL LECTURE ROOM

eight, six and four volts, respectively. It will be noted that, with only one or two exceptions, any voltage from two to forty-two, can be obtained in steps of two volts. Each group of cells is wired to a two-pole, double-throw switch on the battery charging panels E and F in the motor room. These switches, when thrown down, connect the various units of the battery with the battery distribution board in the electrochemistry laboratory, and when up, to the charging mains. In order to avoid voltage fluctuations incidental to "floating the battery on the charging line," it is frequently necessary to charge certain units while the others are discharging. This has been made possible by ingenious interlocking single-pole switches, which throw simultaneously with the charging switches. These singlethrow switches merely complete the circuit for the charging current, across any units which may be discharging. It is obvious that were it possible for a single-pole switch to be closed while its companion double-pole double-throw switch is in the "charge" position, the net result would be a short-circuited battery unit. A special spring interlocking device prevents this possibility by permitting the single-throw switch to close only when the double-throw is in the "discharge" position. In the charging circuit are rheostats, ammeter, voltmeter and circuit breaker, with both overload and reverse current release features. By throwing a double-pole, double-throw switch one can charge from the 55 or the 110-volt mains, as conditions require.

Close inspection of Fig. 2 will show the details of these switches, while Fig. 5 is a larger scale diagram of the wiring arrangement on panels E and F.

For distribution of storage battery energy, the positive ter-

laboratories, and the electrochemical lecture room, all three wires are brought to suitable wall and table switchboards, so that it is possible to obtain either 55 or 110-volt current, up to 25 amperes.

The storage batteries are located near the power room. Light is doubtless more provocative to sulphation of lead cells than is electrical abuse, consequently daylight has no access to the battery room, but ample ventilation has been provided. At present the installation consists of twenty-one 100-amperehour, lead cells, arranged in eight groups, to give four, eight, six, four, two,

FIG. 8—GENERATOR FOR SINGLE-PHASE CURRENT

FIG. 9—CONTROL PANELS FOR HEAVY ALTERNATING AND DIRECT CURRENTS

minal of group 1 is brought to the positive position on the panel in the electrochemical laboratory (Fig. 6). A common wire connects the negative of group 1 and the positive of group 2 to the second receptacle; a third, the negative of group 2 and the positive of group 3, to the third receptacle, and so on down to the last, which c o n n e c t s the negative of group 8 to the negative position on the distribution board. It will be seen that only nine sets of receptacles are required to handle the eight groups of cells.

From this distribution switchboard wires run to each working place in the electrochemistry laboratory, to lecture rooms, and to all l a b o r a t o r i e s throughout t h e building, and terminate in knife switches, w i t h wing connecting lugs, mounted on small wall panels. These circuits are fused for 20 amperes. Connection is made between battery lines and distributing lines by means of flexible cords. Any voltage within the limit of the battery may be impressed on any circuit. This layout is shown in detail in Fig. 6.

In the electrochemistry and metallurgical lecture room is mounted a demonstration switchboard (Fig. 7) very similar to the one described by Bancroft,[1] ex-
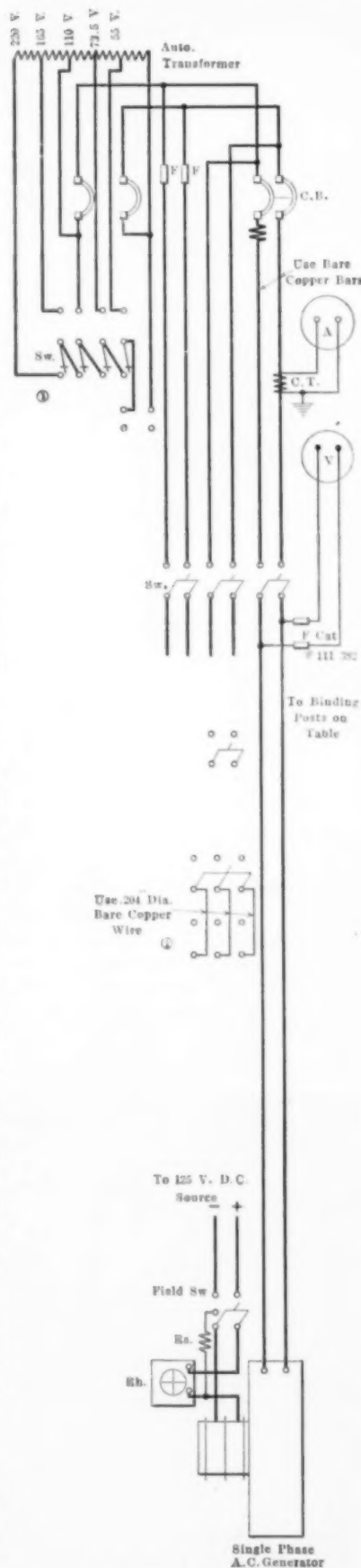
FIG. 10—WIRING FOR CONTROL
PANEL IN METALLURGICAL
LABORATORY

1. Transactions of the American Electrochemical Society, 9, 333 (1906).

cept that we have 42 volts available, while he had 30. This board is fed direct from the charging panel, and is not dependent for its current upon flexible connections, which might be disarranged during a demonstration.

The lecture table has a double set of binding posts marked A, 1, 2, 3, 4, 5, 6 and 7, for tapping off the current controlled by this switchboard. Station type ammeter and voltmeter are mounted on the wall above the table for giving current indications on all possible combinations. Several plug connections are provided, set flush with the table top, giving 110-volt alternating current, or 55-110-volt direct current. A bank of rheostats controlling these latter circuits is mounted under the center of the table.

Power for heavy electrochemical and metallurgical operations is obtained from a 62½-kva., 60-cycle alternator, or from a 24-kw., 35-100-volt direct-current generator.

The alternator set (Fig. 8) comprises a 10-120-volt, 825-ampere, 60-cycle generator, with its 6-kw., 120-volt exciter, coupled direct to a 100-hp., 2200-volt, 1200-rpm., 3-phase synchronous m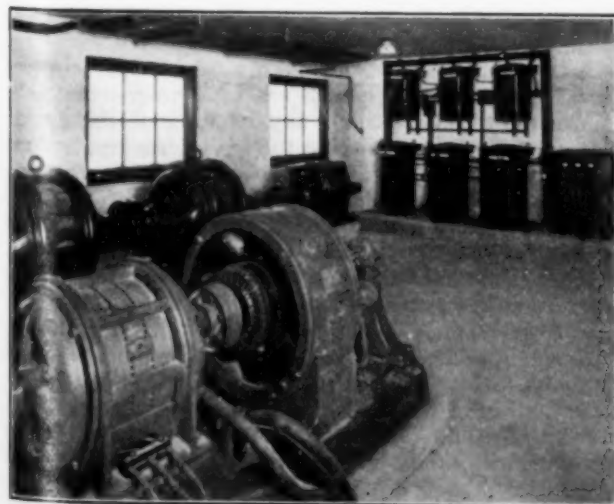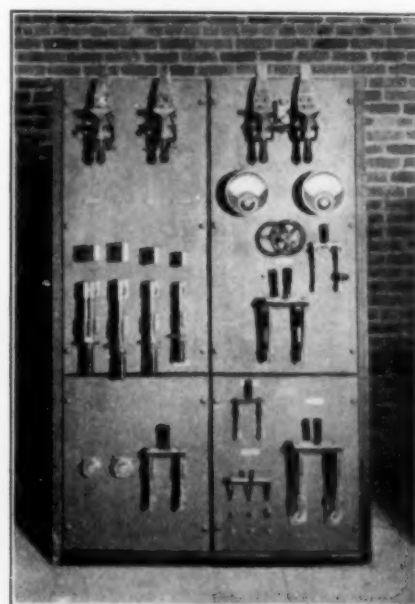otor. The motor is protected against overloads by maximum current, no voltage, and inverse time overload relays, operating the line oil switch. The first requirement of a plant furnishing power for experimental furnace operation is flexibility, owing to the varied characteristics of the many types of furnaces which are to be operated. With this in view, the machine and transformer have been so designed that it is possible to obtain a voltage range of from 0 to 250, in practically an infinite number of steps; and a current range of from 0 to 1500 amperes below about 40 volts, or from 0 to 62500/V amperes above 40 volts. If higher current values are desired for a short time they may be obtained within the ability of the machine to care for short-time overloads.

The voltage of the generator, normally 110, may be decreased to practically 0 or raised to 125 by means of a field rheostat mounted on the control panel in the metallurgical laboratory, Figs. 9 and 10. A field switch mounted below the rheostat makes it possible to cut off the power quickly without serious arcing across the line switch. The generator delivers its power to an auto-transformer mounted directly behind the control panel. Taps brought out from various windings of this transformer enable one to draw current at 55, 74, 110, 165 or 220 volts, when the generator is excited to 110 volts; or at proportionally lower voltages when excitation is lower. Transformer and leads are protected by two double-pole overload circuit breakers, one on the primary side set at 800 amperes, the other on the secondary to open at 1500 volts. Transformer taps are connected with the furnace leads through a series of fool-proof interlocking switches, which are so arranged that it is impossible to short-circuit any winding of the device. Furnace leads are connected to lugs on the front of the control board. A 500-ampere line extends to an electric welder in the rear of the metallurgical laboratory, and a 250-ampere line to the office of the assistant professor of physical chemistry. An ammeter and a voltmeter, both on the primary circuit, enable the operator to keep track of power consumption.

A 24-kw. motor generator set, driven by a 40-hp., 1200-rpm., 3-phase, 220-volt induction motor, has been provided for direct-current furnace operation. The installation of a separate unit for this purpose was deemed advisable, owing to the fact that classes in the metallurgical and electrochemical departments are scheduled in such a manner that two machines will at times be necessary to supply the demands. This machine is shown in the left foreground of Fig. 4, and is

designed to deliver power at from 10 to 100 volts, with a current maximum of 1000 amperes. Since constant voltage is frequently desired for direct-current work, a special voltage regulator has been installed on panel J of the main switchboard which will automatically maintain any desired voltage from 25 to 80. The generator may be self excited, or excited from the synchronous converter. Hand regulation may be had when required.

The control panel for this machine is located on the main switchboard in the power room (panels I and J). On it are mounted motor-ammeter, generator-ammeter and voltmeter; field switch, voltage regulator, field rheostats, line switch and circuit breakers. In arc furnace operation it is necessary that the student whose duty it is to handle the switchboard be able to control or supervise the control of the electrode separation. Since in operating this machine this individual is at some distance from the furnace an electric hoisting and lowering device, controlled at the panel of this generator, has been designed to operate the electrodes. This device is driven by a ½-hp., three-phase motor, controlled by a three-pole, double-throw switch.

Cables for distributing power from this machine to furnaces are attached to lugs on the front of the switchboard in the metallurgy laboratory. Two 100-ampere lines run to the electrochemistry room, making it possible to carry on low-voltage electrolyses of high-current requirements in that laboratory.

Cincinnati, Ohio.

Is Not Gas Power Cheaper Than Water Power?

By H. G. H. Tarr

Some years ago the writer published an article in one of the mechanical journals the title and subject of which was almost identical to this.

The only recognition it received, so far as the writer knows, was a most cordial letter from the late George Westinghouse, who was ever alert for a new idea, however startling. He had investigated the Mond by-product system in England and indorsed in its entirety the premises and conclusions of the article.

There is a new condition now, and this country must of necessity do something not only to conserve her agricultural resources but strengthen her defenses. Curiously these are very closely allied; in fact, they are inseparable and alike dependent upon cheap power.

In view of this I am emboldened to risk again want of recognition by presenting here revised facts and figures that are not wholly new, and data of that which is being done in England and in continental Europe, in hopes that it may arrest the attention of either one of the masters of progress—Capital or the Government.

Everyone knows that without nitrate war would be impossible, and everyone knows equally well that nitrate is the life giver to all that grows. Therefore it is the one life sustainer, and the life destroyer.

We all know as well that there are two sources of supply of nitrate: Chili (for all that has been found on the surface of the earth aside from Chili is a negligible quantity) and the air we breathe. As the supply of the former is subject to more vicissitudes than Antonio's Argosy as described by Shylock, we, like the Germans, must of necessity fall back upon the air we breathe.

When the European war began the world was surprised to learn from shipping statistics the enormous imports of sodium nitrate from Chili into Germany. In addition to this they commandeered all that destined for fertilizer and purchased the output of the "from-the-air plants" of Norway. That was preparedness.

Notwithstanding this the war would now be at an end upon terms dictated by the Allies but for Germany's synthetic plants and processes; so it follows that as a life destroyer it is as essential to the life of a nation as a life-giver or a life-sustainer.

We therefore reach the conclusion that the production of nitrate from the air is a nation's only means of safety as well as prosperity, and as power is essential to this, the all important problem is cheap power.

Is it not possible that we imagine water to be the only very cheap power because we have grown up to think of it as such from the very days when we went swimming in the old mill dam and watched the big wheel go round? And is it not true that when we examine a modern water power plant and calculate its cost from land damages to thermal results we wonder if the old miller didn't take more toll from the grain than the law allowed. Else how did he support his family? However this may be, we fail to find many of the larger water power enterprises paying dividends. So it is possible that except under most favorable conditions power from coal may be cheaper than from water, thus the comparison will be interesting.

Let me first describe briefly the process by which it seems possible to attain this end, the by-products gas producer.

It is the invention of Dr. Ludwig Mond, F. R. S., and was first put into operation at the Brunner Mond Chemical Works in England. It will be remembered that all bituminous coal contains more or less nitrogen and upon the nitrogen content depends the value of the coal for this process. English coals have rather more than American, ours rarely going over 1.5, which is rather unusual.

The producer gasifies all of the coal, and the process extracts from the gas the nitrogen in the form of sulphate of ammonia. There is obtained from a net ton of coal about 140,000 ft. of gas having a heat value of 135 B.t.u. per cubic foot, and if the coal gasified has a nitrogen content of, say, 1.2, it gives about 70 lb. of sulphate of ammonia.

The coal is gasified at a comparatively low temperature to avoid the destruction of the ammonia, this low heat being maintained by introducing steam. From the producer the gas passes through a regenerator, so arranged that part of the heat of the gas and steam is transferred to the blast of air entering the producer. It is then delivered to a mechanical washer where the dust and soot is washed out and the gas further cooled.

After the gas has been washed the next step is the recovery of the ammonia contained in it, and for this purpose it goes to the acid tower, passing upward. Here it comes in contact with a descending spray of a weak solution of sulphuric acid with which it enters into combination, thus forming sulphate of ammonia. This solution of the sulphate of ammonia circulates again and again until it has attained a strength of 36 to 38 per cent at which it is drawn off and evaporated. The gas having now given up its ammonia is passed through another tower for final cleaning and cooling and is ready for use, unless it is to be used for power in a gas engine; then it passes through a tar extractor by which almost the last trace of tar is removed.

In making the comparison between water and gas power, we will consider the proposition of gas-fired steam boilers and the use of steam turbines. This seems to work out better than gas engines from every point of view, the most important being a much cheaper and more dependable installation. The coal economy of the gas engine may be a little higher, but if the by-products are worth as much as the coal costs why consider coal economy seriously?

For comparison it is perfectly fair to locate our gas plant directly at the mine and save all coal transportation. Water power must be where water flows so let us locate gas power where the coal is mined.

There are hundreds of coal mines as near Pittsburgh, Cleveland, Cincinnati, Columbus, Indianapolis, Omaha, Baltimore and many other great cities and centers of population, as we would expect to find any considerable water power. Aside from this in considering a nitrogen plant the transportation of the product is not a large tonnage, in a gas plant approximately 15 per cent that of coal. As there are no transmission lines in either case they are not considered.

The cost of the water plant is taken from the report of a reliable engineer on a plant erected in the West, and by comparison with the costs of several other large plants it seems fairly correct.

20,000-Hp. WATER POWER PLANT

Cost of 20,000-hp. water power plant in 1908 estimated as $3,555,-000. Assuming an increase in cost of 50 per cent. the same plant would cost now $5,333,000.

Operating Cost per Year

Labor	$60,000
5 per cent interest on $5,333,000	266,500
Sinking fund	150,000
Repairs and depreciation	139,500
Taxes and insurance	40,000
Total operating cost	$656,000

Income Water Power Plant

Considering a load factor of 85 per cent, an average of 17,000 hp. will be delivered every day in the year equal to 111,100,000 kw.-hr. per annum. Assuming for comparison that 1 kw.-hr. sells at 1c., the total income per year would be $1,111,000

Profit of Water Power Plant

Total income as calculated above	$1,111,000
Total operating cost calculated above	656,000
Profit per annum	$455,000
or 8.5 per cent on total investment of	$5,333,000

20,000-Hp. STEAM POWER PLANT WITH MOND BY-PRODUCTS RECOVERY

In 1908 we calculated the cost of the gas plant at $600,-000. The present-day cost will be about 50 per cent higher, or $900,000

The boiler plant would consist of 8000-hp. boilers for active service and 2000-hp. boilers for spare capacity, or a total of 10,000 boiler hp. Estimating the cost at $30 per boiler horsepower, the boiler plant will cost erected $300,000

The turbo-generator plant would consist of 20,000-hp. turbo generators for active service and 6000 hp. for spare, or a total of 26,000 hp. Estimating the cost at $40 per horse-power the turbo-generator plant will cost erected $1,040,000

The total investment of the steam plant, therefore, would be as follows:

Cost of coal lands, say	$500,000
400-ton Mond by-product gas plant	900,000
20,000-hp. turbo-generator plant	1,040,000
Cranes	12,000
Switchboard	34,000
Boiler building	80,000
Generator building	50,000
Incidentals	244,000
Total investment	$2,860,000

Operating Cost per Year

Labor	$70,000
Interest, 5 per cent on $2,360,000	118,000
Interest on coal lands cost of $500,000 at 5 per cent	25,000
Sinking fund	100,000
Repairs and depreciation	130,000
Taxes and insurance	30,000
Coal, 149,000 tons (2 lb. per horse-power hour) at $1.50	224,000
Acid (1 ton per ton of sulphate) at $12	63,000
Total operating cost	$760,000

Income Steam Plant

Current at 1c. per kilowatt-hour as before	$1,111,000
Sulphate (70 lb. per ton of coal) at 3c. per pound	312,900
Total income	$1,433,900

Profit of Steam Plant

Total income as calculated before	$1,433,900
Total operating cost calculated before	760,000
Profit per annum	$673,900
or about 23 per cent on total investment of $2,860,000.	

From this it would appear that a by-product gas plant is more economical than a water power by about 14.5 per cent under the same conditions of load. etc.

These figures being approximately correct, the first question that will be asked is, "How near is it practicable, and how much is experimental." The answer is, "Entirely practicable and not at all experimental." Bear in mind we are speaking of a power plant to generate electricity for a nitrogen plant.

There were in operation in England ten years ago six of these plants aggregating 110,000 hp., varying in size from 10,000 to 25,000 hp., and ten or twelve smaller ones.

Brunner Mond's enormous chemical works are run entirely on by-product gas. In South Staffordshire there is a central plant distributing this gas over an area of 123 square miles and supplying heat and power to about 2000 industrial plants. There is a 12,000-hp. plant in Spain that uses its lean brown coal that is rich in nitrogen, however, and one in Buenos Aires. In France and Germany there were several before the war. Of how many now we have no knowledge.

In this country there has been only one built, which ran for several years with perfect uniformity both in quality and quantity of gas and sulphate of ammonia produced, but is now closed down for causes not at all attributable to the gas plant.

There are several reasons why we have not built more of them. Similarly, the first cost is too much per horse-power, when considered in combination with the gas engine, and heretofore only a combination with this form of motor has been considered; but it is the impression of the writer that the day of the by-product gas plant has now arrived as a power producer in competition with the even more expensive installation of an average water power.

Are American coals suitable for the by-product process? Some are and very many are not. As we have said, our coals are not as rich in nitrogen as the English, for in England they get from 90 to 100 lb. of sulphate of ammonia per ton from many, while 80 lb. would be a high result here. There are so many good coals here, however, that we need not despair of getting high results. The coals of Pennsylvania are not suitable, as no highly coking or caking coal is. Hocking Valley has been used in large quantities with excellent results. Southern Indiana has some coals that are excellent. Of all that have been tested for this purpose the best were from Kentucky—high in nitrogen while they burn freely and do not cake or coke in the producer. Aside from this any coal that has sufficient nitrogen content is suitable, and it is believed that present studies will develop a producer that will overcome this obstacle.

In the foregoing estimate we observe that we have consumed 149,000 tons of coal and produced (70 lb. per ton of coal) 522 tons of sulphate of ammonia.

A favorite mixture of fertilizer for cotton is 200 lb. acid phosphate, 85 lb. of kainit, and 100 to 150 lb. of nitrate of soda to the acre. The nitrate of soda can very well be, and is in many cases, replaced by sulphate of ammonia which furnishes 23 to 25 per cent of ammonia, whereas nitrate of soda has nitrate equivalent of about 19 per cent. If 100 lb. of sulphate are used in the mixture for an acre our imaginary plant would supply the ammonia for 10,400 acres of cotton every year. How much cotton or corn this would grow is beyond the writer, but would it not be most interesting and instructive to follow the thought and calculate how much cotton could be grown from the nitrogen burned up in the coal consumed for power in the state of Georgia, for instance? But—"that's another story."

R. D. Wood & Co.,
Philadelphia. Pa.

Notes and Experiments Pertaining to the Metallurgy of Zinc

By Edward Mackay Johnson

Supt., Eagle Picher Lead Co.

In this article and others that are to follow, the author proposes to discuss phases of zinc metallurgy that will be of interest alike to students of the subject and to experienced operators. For the former class of readers there will be introduced some discussions of an elementary nature, as well as items having only an indirect bearing on the improvement of the art. For those of experience there will be given the results of practical experiments on a large scale designed to fill some of the gaps left by more prominent writers on the subject. The entire discussion will be based on the author's practical experience and personal observation at a number of the zinc smelters in the United States, and is offered in the hope that it will both supplement and confirm previous publications.

While technically the metallurgy of zinc is at least no more difficult than that of the other common metals, it involves a mass of minute details that exert an influence on the ultimate recovery of the metal. These will be discussed in the following order:

I. Preparation and roasting of the ore, including a discussion of different types of charge fuel and methods of mixing.

II. The pottery; manufacture of retorts and condensers; experimental records and costs.

III. Furnaces; details of operation; furnace temperatures with many experimental data on firing.

IV. Spelter production from typical ores; sampling and analysis; treatment of retort residues.

As a rule zinc ore is received at the plant either in the form of concentrates or as lump ore. Generally the concentrates are in a suitable condition or size to go directly to the roaster. If the ore be received in the lump form, it is of course necessary to crush and size it. The size varies for different ores, and for the same ore at different plants, using a revolving screen of 5-mesh, No. 14 wire, 7-mesh, No. 16 wire, or 6-mesh, No. 16 wire. The stationary sloping piano-wire screen also is used.

The most important point, however, to bear in mind is to have ample screening capacity, so as to remove the fine material as fast as it is crushed to pass the screen openings, thereby having as great a percentage of the ore as near the size of the screen opening as possible, and no more dust than can be avoided. The above point is well known but often neglected, both in designing the crushing and screening department and in the operation of the same.

FORMATION OF DUST IN RABBLING

The problems encountered in roasting, and the failure to overcome them, are due not only to insufficient knowledge of the requirements of a roaster to do good work, such as regulation of air, heat, rabbling, thickness of bed, and chemical reactions, but also to the mechanical construction of a roaster to accomplish these results. Take, for instance, the question of rabbling or stirring. There is no doubt that an ore should receive the proper amount of stirring or turning over to do good roasting; at the same time the operation can be overdone as shown by the results given in Tables I and II.

The main point brought out by these figures is that the ore may be stirred or rabbled by a certain mechanical rabble in such a way as to increase the percentage of fine material between the feed and discharge ends of a kiln. This not only increases the dust loss but

TABLE I
Screen test of a Typical Ore

Mesh	Stirred with Little Grinding Effect		Stirred with More of a Grinding Effect	
	Green Per Cent	Roasted Per Cent	Green Per Cent	Roasted Per Cent
On 10	29.0	13.4	11.0	9.7
On 20	19.6	20.9	25.0	21.6
On 30	11.5	17.1	16.2	12.6
On 40	7.3	10.5	9.2	8.0
On 50	5.6	8.0	7.5	6.2
On 60	0.4	1.0	0.7	1.3
On 80	12.7	15.6	13.4	15.0
Through 80	13.0	12.7	15.7	24.5
	99.1	99.2	99.7	98.9

TABLE II
Screen Test of Another Typical Ore Giving Same Comparison as in Table I

Mesh	Green Per Cent	Roasted Per Cent	Green Per Cent	Roasted Per Cent
On 10	3.13	11.25	5.63	7.13
On 20	15.62	20.00	23.13	16.94
On 30	17.50	15.63	14.37	11.88
On 40	13.13	9.38	10.63	7.50
On 60	9.38	8.75	7.00	5.64
On 80	20.60	20.00	17.50	13.75
Through 80	18.13	13.75	20.00	34.37
	97.49	98.76	98.26	97.21

makes it a little more difficult to obtain as good results in roasting.

REGULATION OF HEAT, AIR AND RABBLING

While the writer has had considerable experience in practical roasting, he feels incompetent to discuss intelligently the theoretical questions relating to heat, air and chemical reactions and will offer only a few practical suggestions.

Each type of roaster has to be practically regulated relative to the amount of heat and air necessary to do good roasting, and sufficient rabbling must be given the ore to expose every grain to the action of heat and air. This regulation also varies for different kinds of ores. In practical roasting it is well to consider three classes of ores which are often received at zinc works.

First Class.—Under this class would be placed what are called hard ores, such as Joplin, Wisconsin and some of the Western ores. These ores do not give up their zinc very readily, and require harder firing in the zinc furnace. As a rule they are low in iron and the sulphur is practically all combined with the zinc. The so-called "free" atom of sulphur is present to only a small extent. The ore, therefore, in the feed end of the kiln does not generate much heat by the combustion of this free atom of sulphur. For this reason, in roasting this class of ore, it is advisable to aid and force the process by the use of extraneous heat as much as possible, without in any way sintering the ore in the first stages of roasting, gradually increasing the heat toward the discharge end of the kiln.

Second Class.—Assume this ore to be concentrates carrying 10 per cent to 15 per cent of iron in the form of pyrites. Due to the combustion of the free atom of sulphur in the first stage of the operation considerable heat is generated. It is, therefore, at the feed end of the kiln that advantage must be taken of this fact to economize in the use of fuel. It is sometimes not necessary to introduce any extraneous heat before the middle of the kiln is reached, and then force the roasting as fast as possible by increasing the heat to the discharge end of the kiln. In either of the above cases it is well to retain a good heat in the kiln for about 20 ft. near the discharge end. The writer's experience has been that a certain percentage of the sulphur left in the roasted ore is nearly always in the form of sulphate. The fact should, therefore, be kept in mind that it is immaterial how the sulphates are formed, or how much the ore is rabbled, or how long it remains in the kiln; the sulphates will not be broken up if the necessary heat is not provided.

Third Class.—Under this class would be considered the dust from dry concentrating plants and slime from wet mills. This class of material is dreaded by the metallurgist, both in roasting and in the distillation of zinc, and he rarely attempts treating it alone but mixes it with concentrates or crushed lump ore before roasting.

Dust and slimes are not only objectionable due to their fineness, with consequent high dust loss, but they nearly always carry considerable lead, lime, etc., which add to the difficulties of roasting and distillation. It would be more satisfactory, at least metallurgically, if the dust and slimes could be converted directly into a pigment. This is done to a certain extent, but due either to the commercial difficulties or to the losses of silver and gold, only a part of such material is now handled in this manner.

EFFECT OF UNROASTED SULPHUR ON ZINC RECOVERY

In considering the sulphur left in the roasted zinc ore it is customary at the plants to determine what is termed "faulty" sulphur (which is that sulphur existing as sulphide and soluble sulphate) by determining the per cent of sulphur combined with the calcium and lead that may be present, and deducting the same from the total sulphur found. It is generally assumed by the metallurgist that the sulphur existing as "faulty" sulphur exerts the most deleterious effect upon the recovery of zinc; while the sulphur combined with the lime and lead in the form of sulphates is not broken up or liberated, and consequently does not affect the results to such a marked degree.

Just why and for what reason sulphur has such a bad effect upon the recovery of zinc; and whether the effect is due mainly to chemical reactions taking place in the retort, thereby retaining zinc in the form of oxide or sulphate, or whether it is due to poor condensation of the zinc vapor, remain unsettled questions. So far as the writer's experience goes, there is no way of firing the furnace to overcome the effect, and the old rule of one per cent of "faulty" sulphur retaining two per cent of zinc holds good.

The sulphide sulphur has at least another bad effect upon the recovery of zinc which is sometimes lost sight of, and that is the formation of matte, which is exceedingly corrosive in the retorts. The fireman, in order to save his retorts from butchering, does not carry the distillation as far as he might otherwise do, with a consequent loss of zinc in the residue. On the other hand, if the fireman or superintendent insists upon working off the furnace, a high retort loss ensues which causes a loss through the absorption of zinc.

CHARGE COAL

This material may be divided practically into four classes, as follows:
1. Soft or dead coal.
2. Arkansas slack; semi-anthracite.
3. Anthracite screening.
4. Coke or coke breeze.

The first and second classes are used principally at the plants in the natural-gas field, while the third class is almost exclusively used at the coal-field plants. A small proportion of coke is used at times at some of the plants in both fields.

Dead Coal.—This fuel comes from near the surface of the ground, and in a good many cases is simply the strippings of the mine. The best grade of this coal answers very well as charge fuel, but some of it is of a very inferior quality. Each car of coal should be inspected before it is unloaded and if there is any doubt about its value a proximate analysis should be made.

A determination of the ash can be quickly made and is one of the best indications of the grade of coal, aside from a physical examination.

The following analyses are fairly representative of dead coal as received at the plants.

	Moisture Per Cent	Volatile Matter Per Cent	Fixed Carbon Per Cent	Ash Per Cent	S Per Cent
No. 1	1.8	27.07	63.0	6.8	1.00
No. 2	8.0	23.0	60.0	7.5	0.87
No. 3	2.0	23.0	60.0	12.5	1.85
No. 4	5.0	24.2	62.0	7.5	0.79
No. 5	4.1	23.4	52.4	20.1	....

The dead coal as received at the works is too coarse to be mixed in the charge and has to be crushed to a suitable degree of fineness. This varies somewhat at the different plants but rarely exceeds ½-inch. As this is practically the only requirement regarding the size of this coal, the method of obtaining the same is simple. Of late years the hammer type of breaker has replaced the jaw type crusher or corrugated rolls at some of the plants and is giving satisfaction especially for wet coal.

Arkansas Slack.—This coal is received in the form of screenings from the mines of Arkansas. Previous to its introduction as a very situable material for the reduction of zinc it was practically a waste product, and could be bought for $0.25 per ton at the mines. As soon, however, as the plants commenced to compete for this coal the price immediately jumped up and has continued to increase until at the present time it is at least $1.30 per ton at the mines. Even at this price it still continues to compete with dead coal. Arkansas slack is sometimes used alone and sometimes mixed with dead coal in varying proportions. The experience of the writer is that when Arkansas slack is used the retorts clean out better, especially when Colorado or Western ores are being treated. In the case of one such as Joplin concentrate a mixture of ¾ dead coal and ¼ coke works about as well; any possible slight gain in the use of Arkansas slack being offset by the increased cost of that fuel.

The following analyses were made on some cars of Arkansas slack being used at one of the zinc plants a number of years ago.

	Moisture Per Cent	Volatile Matter Per Cent	Fixed Carbon Per Cent	Ash Per Cent	S Per Cent
No. 1	2.1	18.7	64.8	14.4	2.3
No. 2	2.1	11.3	72.3	14.3	2.4
No. 3	7.3	8.7	73.1	10.9	1.1
No. 4	5.2	6.5	72.1	16.2	2.4
No. 5	6.4	11.8	68.1	13.6	1.5

The sulphur driven off with the volatile matter was not considered, which accounts for the analyses footing up a little too high.

Arkansas slack deteriorates very little if any upon standing, and is not inclined to fire when stored. The writer has known of one or two instances where a pile of Arkansas slack was on fire, but is inclined to think it was due to the fact that the cars in which it was shipped had not been thoroughly cleared of a previous shipment of bituminous coal. The use of Arkansas slack as a charge fuel has practically been restricted to the plants in the natural-gas field.

Anthracite Screenings.—This is the principal charge fuel now being used at the various zinc plants throughout the coal field east of the Mississippi River.

This material is similar to Arkansas slack, but is somewhat more satisfactory as a charge fuel. It is a little lower in ash and sulphur and a little higher in fixed carbon. It is obtained principally from the coal docks, and when received at the zinc works does not require any further preparation before being mixed

with the ore. By the use of anthracite screenings a little more charge can be handled, and the retorts will clean out better than with many of the other kinds of coal.

Coke.—This class of charge fuel has never become extensively used. It has found a greater application in the plants of the gas fields than in the coal field, the amount seldom exceeding 25 per cent of the total fuel used. It is usually mixed with dead coal, and for certain ores it is more satisfactory than dead coal alone. When coke is used the residue does not clean out of the retorts so well, and in general there is very little to be gained by its use unless it is obtained very cheap.

Percentage of Charge Coal to Ore.—This varies from about 40 per cent to 60 per cent, according to the kind of ore being smelted, and represents the ratio of the pounds of fuel used to the pounds of ore as charged to the furnace. In extreme cases the percentage of charge fuel may go a little below 40 per cent or a little above 60 per cent. The proportion of coal used to the ore charged is governed by the way the residues clean out of the retorts, and consequently by the analysis of the ore. There is one exception at least to this, and that is when the ore carries such a high percentage of zinc that the tonnage is somewhat limited by not being able to work the furnace off dry enough. The difference has to be made up with fuel, and in this particular case it is policy to use a cheap grade of material. The burden or weight of charge that the retorts will stand also enters into the above exception.

MIXING THE ORE AND COAL

So far as the recovery of zinc is concerned, the method of mixing the charge is immaterial, but it is very essential that an intimate mixture of the coal and ore be obtained. The methods of getting the ore and coal to the mixing room differ somewhat at the various smelters, according to the arrangement of the plant and the amount of money available for the construction.

One very satisfactory arrangement is to have overhead steel bins with hopper bottoms, constructed with cut-off chutes so that the ore may be drawn off into tram cars. In one particular instance the tram cars have been replaced with traveling crane buckets electrically driven and holding from 2 to 5 tons of ore.

There are two important points to be kept in mind when considering the handling of ore at a zinc plant, namely, the low tonnage and the dust loss. Due to the small tonnage treated it takes some time to pay for any expensive mechanical installation; and by the time it is paid for it has to be replaced. Therefore, unless a reduction in dust loss be accomplished, it is questionable whether such expensive installations pay. This question will be discussed a little later on.

Mixing.—The actual mixing of the coal and ore differs in some way at nearly every plant. One of the oldest methods, and one that is still being used at some plants, is the pit or "lay-down" system. Two adjacent pits are constructed into which alternate layers of roasted ore and coal are spread until a charge is made up. The pits may be large enough to handle the mixture for either a half or whole furnace, according to whether two charge cars are to be used or only one. The latter method gives the best results due to the fact that the poorest mix obtains at the beginning and end of the process of feeding out of the pits into the elevator. In the first method this factor would come into play four times as against twice in the latter. Due to the high cost of the method and the poor mix resulting, especially when two charge cars are used, the pit system has been replaced at a number of plants by the concrete-mixer into which the coal and ore in proper proportions are fed in successive batches.

Quantity of Water Necessary.—Owing to the different degrees of fineness of the various ores, and to the variable quantity of moisture contained in the coal, careful attention must be given to secure a mix of proper consistency, neither too wet nor too dry. If the mix is too wet the furnace charger can not charge as fast nor as well, and the excess moisture has the bad effect of cooling the retorts, which in extreme cases would cause them to crack. Again any cooling of the retorts delays the process of distillation and increases the consumption of firing fuel. On the other hand if the charge is too dry, the charger can not get as much charge into the retorts, and the dust loss will be a little higher.

Cost of Mixing.—Table III illustrates the cost of mixing at different plants in the natural gas field and coal field under both the pit and concrete-mixer systems. The table affords an opportunity to compare costs and to judge how far one may be justified in installing mechanical means for handling and mixing the charge.

TABLE III

Case No. 1

Natural Gas Field; Pit System; 4-Block Plant; 70 Tons Green Ore Per Day

1 foreman at $2 per day	$2.00
7 men at $1.75 per day	12.25
Total cost per day	$14.25
Cost per ton green ore	0.204

Case No. 2

Natural Gas Field; Pit System; 5-Block Plant; 85 Tons Per Day

1 foreman at $2.25	$2.25
4 transfer men at $2	8.00
1 car man at $2	2.00
1 car boy at $1.50	1.50
1 box boy at $1.25	1.25
Total cost per day	$15.00
Cost per ton green ore	0.176

Case No. 3

Coal Field; Concrete Mixer; 5-Block Plant; 110 Tons Per Day

1 foreman at $3	$3.00
6 men at $2	12.00
1 box boy at $1.25	1.25
Total cost per day	$16.25
Cost per ton green ore	0.148

Case No. 4

Natural Gas Field; Pit System; 5-Block Plant; 88 Tons Per Day

1 foreman at $2.50	$2.50
6 men at $2	12.00
1 man at $1.85	1.85
Total cost per day	$16.35
Cost per ton green ore	0.188

Case No. 5

Coal Field; Pit System; 5 Block; 100 Tons Per Day

1 foreman at $2.75	$2.75
2 men at $2.15	4.30
10 men at $2	20.00
Total cost per day	$27.05
Cost per ton green ore	0.2705
	.08
	$0.1905

In this case the ore had to be unloaded by the mix-room men direct from box cars, which saved 3c. per ton

Case No. 6

Natural Gas Field; Concrete Mixer; 7 Blocks; 125 Tons Per Day

1 man at $3.50	$3.50
2 men at $3	6.00
4 men at $2	8.00
Total cost per day	$17.50
Cost per ton green ore	0.14

For the sake of comparison take No. 4 as representative of the pit system, using neither concrete mixer, overhead bins, nor expensive mechanical arrangement for getting the ore to the mixer. Take also No. 3 with overhead bins costing say $15,000. Take No. 6 with bins costing $10,000 and electric traveling buckets from bins to mixer costing say $5000.

The difference between the first case and either of the last two cases is 5c. per ton; or, on the basis of 100 tons per day, $5 per day, or $1825 per year. At this rate it would require nine years to pay for the installa-

tion, without figuring anything for interest on the investment.

Suppose we assume an investment of $15,000 that will result in saving ½ of 1 per cent of the tonnage as dust and that the plant is treating 100 tons of ore per day; ½ of 1 per cent of 200,000 lb. equals 1000 lb. of ore per day. If this dust be valued at only $20 per ton the saving would amount to $10 per day, or $3650 per year and at this rate 4¼ years would be required to pay for the installation.

ORE MIXES

Quite a number of the plants are required to treat various types of ores, all of which are different in analysis; and while these ores are mixed with a view of obtaining a better recovery of zinc, or of keeping the per cent of iron as low as possible, no plant, so far as the writer is aware, has succeeded in operating furnaces so as to produce an easily fusible slag in the retorts, as is claimed to be done in Europe. The cause of this difference in operation is probably to be found in two items.

1. Difference in the retorts used.
2. The ores change too frequently.

The first of these objections can, of course, be eliminated; but as seen from the following illustration the second is the most difficult to overcome.

We will assume, for example, that a zinc company has a head office in a certain city, to which important questions must be referred for settlement. Consider that this company retains an ore buyer in the Joplin district, one in the Western States taking care of Colorado, Utah, etc., and possibly another in Montana. Now any one of these men may at any time wire the head office to the effect that he can purchase so many tons of a certain ore on a certain basis. From the knowledge of the results already obtained on this or similar ores, as to recovery and treatment cost per ton, the head official can approximately figure the margin. If the company needs the ore or can advantageously store it, and if the transaction shows a favorable margin, he wires the representative to buy. While the metallurgist may be occasionally consulted, circumstances such as this usually force a continual change of ores upon him.

BAD EFFECT OF CHANGING ORES

There are several reasons why the frequent change of ores has a bad effect upon the operations. In the first place it requires about a week to get the mix properly adjusted, and the foremen accustomed to the change, even when these ores have been handled before. In the case of a new ore it often takes longer than a week. Again, whenever the ore is changed the retort loss usually runs higher for a few days, and if it is a very bad change, like going from a low-grade zinc ore that is high in lead, iron or lime, to a high-grade ore similar to Joplin, all of the retorts may have to be renewed before the loss again becomes normal. The experience of myself and others has been that in such cases it is best to reduce the ore and increase the fuel for two or three shifts to permit the removal of most of the material left in the retorts from the foul ore. Another reason why a change in ores has a bad effect is due to the fact that the retorts and condensers suitable for a high-grade ore are not so well adapted to the low-grade ores.

Although American companies have not been able to properly mix their ores with reference to the formation of an easily fusible slag, the custom prevails of mixing certain ores in order to obtain better results in general, even though the recovery be the same as the average recovery of the ores treated separately.

Take, for example, roasted Joplin sulphide, 60 per cent zinc, or carbonate or silicate ore containing about 35 per cent zinc. Assume that the tonnage of Joplin ore going to the furnace is restricted to a certain amount on account of working off the furnace, or due to the burden the retorts will stand. Assume the fuel to be ample. In such a case it would be better to cut down on the Joplin ore and reduce the fuel, replacing both with the silicate ore, thereby putting through a greater tonnage.

Another well-known case of mixing is where one ore low in iron, lead or lime, is mixed with an ore high in these elements. This mixture not only has the advantage of a possible better recovery and a moderate retort loss, but a grade of spelter can be produced containing iron and lead within the commercial limit. If one of these ores should require easy firing and the other hard firing it would be a question from the standpoint of recovery whether it would pay to mix them.

When dust or slimes are treated they are nearly always mixed with some suitable ore or concentrates previous to roasting. It will, therefore, be observed from the preceding remarks upon the change of ores and ore mixes that each plant must work out its own policy according to its particular conditions.

Henryetta, Okla.

A Comparison System for Determining and Standardizing the Grain Size of Annealed Brass

By Geo. A. Miller, Jr.

The proper anneal of brass for the purpose of drawing the metal or otherwise changing its shape by pressure, without melting it, is a very great factor determining the properties of the final product, and in the present-day high cost of tool steel it is important as greatly affecting the life of the tools used in this work. Metallographic testing of brass and copper has therefore come to the front with great strides in aiding to determine, along with the usual chemical analyses, whether or no the specifications are being followed in the preparation of the metal.

Nearly all brass and copper is today purchased according to chemical composition, and also in the cases where the foundry anneals the sheets or blocks of metal there is a specified grain size, at a given magnification, prescribed. These limits are fixed and photographs illustrating these grain sizes are usually attached to the specifications.

It appears, therefore, that the companies furnishing brass and copper to consumers at a specified anneal might do well to adopt a standard magnification and to adopt a standard set of grain sizes similar to those used in the device which is here illustrated. The consumer could then obtain from any producer of annealed brass or copper exactly the anneal he desires by merely specifying that the grain size should be of certain size. There would then be no difference between the metal which company A might furnish or company B. Much of the present trouble would then, I think, be done away with.

It has been found that the different companies which furnish this brass use different systems in determining the grain size. In some cases the skill of the operator as a guesser comes into play and he looks on the screen of the camera and guesses that the anneal of the metal is of such and such a grain size. It is true indeed that after long practice the operator might be able closely to approximate the correct size, but guesswork in a manufacturing company that buys or sells according to speci-

fications is usually costly to someone where accurate specifications are closely followed by the receiving company.

Then again there is the old system of counting the number of grains, across the field of vision, shown on the screen of the metalloscope. The number of grains are then divided into the area of the field covered by the objective. By a direct test of this system in the laboratory of perhaps the largest consumer of brass and copper in the United States, it was found that not one in five men counted the same on one sample of brass without changing it in any way. This can easily be accounted for by the fact that the boundaries of the grains are often indistinct, and in routine work, where many samples are to be examined, the polish and etch cannot be given the same care and attention that a very fine piece of research work might receive. Consequently, these grain boundaries are indistinct, and great care, which is not always possible, must be taken to trace each one out. This method was used for a long time, but finally it was decided that it was too slow and inaccurate.

A set of clear microphotographs were next made, and by counting the grains very carefully and averaging the counts of five men, standard grain sizes were given these photographs. The set consisted of the following sizes: 0.025 mm., 0.030 mm., 0.040 mm., 0.050 mm., 0.070 mm., 0.080 mm., 0.090 mm., 0.100 mm., 0.125 mm., 0.180 mm. These specimens were carefully prepared and photographed so that no mistake might be made in the counting. The sample to be examined was then placed in position on the machine, placed in focus, and the image was compared to the set of photographs

FIG. 2—SHOWING REAR OF DEVICE OPEN TO SHOW LIGHT

FIG. 1—FRONT VIEW OF DEVICE WITH TWO SLIDES
IN POSITION

until the grain size was found. This system was much faster and very much more accurate, and the results obtained by different observers checked to a very close degree of accuracy.

This microphotograph system worked very well indeed and proved to be a great time saver, but some difficulty was encountered in comparing the image on the screen of the camera with the opaque photograph. Therefore, the idea was formed of producing as nearly as possible a condition similar to that of the screen of the camera and to have the grain size show up on the comparing screen as nearly as possible to the image of the camera.

Accordingly, lantern slides were made showing the various grain sizes and were placed in the frame, shown in the accompanying photographs constructed in such a manner that it could be moved up and down to show two slides, carrying photographs of grain sizes which differed by 0.010 mm., in position at the same time, whereby the relative size of the grains shown by the camera image was determined by approximating between the two slides. A half way, or 0.005, approximation was therefore easily obtainable. Very accurate results were obtained in this way, and the various men who operated the machine seldom varied in check reports by more than 0.005 mm., whereas by the old method errors of 0.020 mm. to 0.030 mm. were quite frequent.

These slides were illuminated by means of an electric lamp inclosed in the box (the rear view, Fig. 2, shows the box opened to show light). To further obtain the desired effect, the interior of this box was finished in orange shellac and a sheet of ground glass was placed between the lantern slides and the light. This was found to give very nearly the same condition as that shown on the screen of the camera. A counterweight held the frame at any desired height and the comparison was easily obtained between the slides and the image shown on the screen.

This comparison machine is quite compact. It was easily constructed in the carpenter shop and was easily attached to the frame of the metalloscope by a clamp similar to those used in holding the various parts of the machine on the base. Being constructed of light wood, it is not heavy and does not interfere with the normal operation of the machine.

Philadelphia, Pa.

A Glossary of Terms Used in the Rubber Industry

By Frederic Dannerth, Ph.D.

The rapid advance which has recently been made in the preparation of specifications for rubbergoods has brought with it a desire for more detailed information regarding the terms used in the rubber industry. Phrases such as "up-river fine Para," "Hevea rubber," and "fine Para rubber or its equivalent" are useless unless the buyer and the seller understand each other as to the meaning of the terms. With this in view the writer has taken some pains to obtain from the importers of crude rubber and from the manufacturers of rubbergoods a definite statement.

The terms in Group 1 refer principally to Hevea rubber; Group 2 to organic substitutes for rubber; Group 3 to factory terms; Group 4 to scientific terms; Group 5 to gums related to rubber; Group 6 to terms used in foreign countries.

The author hopes that this glossary will also be of considerable use to those called upon to testify in legal cases involving rubber or rubber products.

GROUP 1—TERMS REFERRING TO HEVEA RUBBER

1. *Fine Para Rubber.*—This material is obtained from the wild *Hevea brasiliensis* trees which are found along the Amazon and its tributaries in Brazil. It is put on the market in the form of "hams" (pelles or biscuits) resembling large watermelons. These hams lose about 20 per cent of their weight when they are washed and dried. They are called hams because of the peculiar smoke odor which clings to the rubber after the smoking (curing) operation. This rubber is characterized by its complete and uniform coagulation. In some cases the buyer will permit a maximum of *one* per cent of uncoagulated or partly coagulated rubber in the ham. This, however, is bad practice, as it is difficult to define 1 per cent.

The ball when cut shows the laminated structure of the ham, due to the fact that it is gradually built up by applying layer after layer of the rubber milk (latex) to the paddle. The layers can be readily separated. On fresh pelles which contain large percentages of water, the layers split off more readily than in the case of well dried specimens. Fresh shipments arriving at the port of New York usually contain not more than 20 per cent of water. Rubber which has been stored will lose more or less moisture according to the length of time it has been stored. If stored in a dry place for a long period, it will lose in weight, and because of the absence of water it will command a higher price in the market. Hence contracts specify "old" or "new" rubber.

Fine Para rubber appears on the market in about twenty-five grades and varieties which vary in (1) tensile strength; (2) water content; (3) percentage of dirt. The grades are named after the several tributary rivers of the Amazon and after the port of shipment. Some of these grades (mentioned in the order of their quality) are: (1) Beni or Beni Bolivian; (2) Madeira; (3) Solimos, Javary, Jurua, Purus, Acre; (4) Mollendo, Angostura, Xingu; (5) Tapajos; (6) Matto Grosso, Caviana, Peruvian, Islands, Tocantins. The first three groups include the best grades. The Knapsack-Madeira grade is especially well adapted for the preparation of cements, and brings a fancy price because of its peculiar virtues. Caviana grade is sometimes made up to imitate the Knapsack-Madeira, and is therefore designated as Knapsack Caviana.

2. *Medium Para Rubber.*—This material prepared from the latex of *Hevea brasiliensis* is next to fine Para rubber in commercial value. It is recognized by the appearance of the ham when viewed in cross-section. Curds and globules of milk imperfectly coagulated are seen between the layers. These uncured spots and badly smoked spots may be only as large as a dime, or they may constitute as much as 25 to 50 per cent of the whole ham. The price is in consequence three or four cents below that of fine Para rubber.

3. *Coarse Para Rubber.*—This is *Hevea* scrap rubber prepared from the residue left in the latex cups. It includes latex which curdled before it could be smoked and made up into fine Para rubber, and occurs in commerce in two principal forms. "Up-river coarse Para" is distinguished from "Islands coarse Para" by being drier and harder, and the spheres or pelles are smaller. "Islands coarse Para" appears on the market in irregular balls about seven inches in diameter. This grade shrinks from 35 to 50 per cent, while "up-river coarse Para" loses 20 to 25 cent when it is washed and dried. Here again we find that brokers make a distinction between "old" and "new" lots.

Experience shows that Islands coarse Para deteriorates considerably when stored for twelve months. It contains as much as 6 per cent of resins in some cases while up-river fine Para rubber hardly ever contains more than 3 per cent of resins. At the present time considerable attention is being given by rubbergoods manufacturers to a determination of the resin content and the protein content of washed and dried rubbers, as it is now generally recognized that these constituents have a marked influence on the speed of vulcanization of the green rubber compound.

4. *Para Rubber.*—This term is used in the rubber market to include Up-river Fine Para Rubber; Islands Fine Para Rubber; Up-river Coarse Para Rubber; Islands Coarse Para Rubber; Cameta Rubber. All of these are prepared from the *Hevea* plant.

5. *Plantation Rubber.*—This term is used in the rubber market to include First latex crepe; Amber crepe; Brown crepe; Smoked sheets; Fine sheets, not smoked. Most of these are prepared from the *Hevea* plant.

6. *Hevea Rubber.*—It was proposed to use this term in specifications to avoid any discrimination between the product of the wild and the cultivated *Hevea brasiliensis* trees.

7. *Wild Rubber.*—That obtained from the Amazon Valley in Brazil and the forests of Africa whether it be from the *Hevea,* the *Castilloa, Hancornia, Manihot, Ficus, Landolphia, Funtumia* or any other rubber tree growing wild.

8. *Plantation Smoked Sheets.*—Rubber which has been hung in a "smoke house" after being coagulated with acetic acid. This method is known as "smoke-drying" to distinguish it from "air-drying." One of the earliest reliable brands put on the market was Highlands Sheet.

9. *Machine Smoked Sheets.*—These are prepared by subjecting thin layers of the rubber latex to the action of smoke in a machine. In this way the latex is coagulated in imitation of the original Brazilian "smoke cure."

10. *First Latex Crepe.*—The finest grade of plantation rubber from the *Hevea* trees in the Middle East. It is prepared by acid coagulation.

11. *Brown Crepe.*—This is filled with particles of bark so that it has to be washed before using. The bark is light and the loss seldom exceeds 5 per cent. This material is stronger than African Sud-kamerun Rubber.

12. *Crude Rubber.*—This term is generally applied to wild rubber which has not been washed and dried.

13. *Washed and Dried Rubber.*—Rubber from any source which has been freed from water and dirt by washing with water on a washing mill. Some rubber prepared on plantations and rubber for use in elastic bands is generally air-dried, but the bulk of all rubber used at the present day is vacuum-dried in specially designed apparatus.

14. *Refined or Broken-down Rubber.*—That which after washing and drying has been run on a warming mill until it is welded into a homogeneous plastic mass. In the case of Hard Para rubbers this is frequently performed sometime ahead of the actual mixing operation, as the operation of breaking down stiff rubber consumes time and retards the actual mixing operation.

15. *Deresinated Rubber.*—This term is preferably applied to washed and dried rubber containing not more than 3 per cent resins. The resins are determined by extraction with boiling aceton for five hours. This term is used specifically in describing Guayule rubber from which the major portion of the 20 per cent resin content is removed.

GROUP 2—TERMS REFERRING TO ORGANIC SUBSTITUTES FOR RUBBER

1. *Scrap Rubber.*—Worn out or discarded rubbergoods. It is purchased by reclaimers of rubber after it has been sorted. The character of the compounds originally used for making the rubber articles determines the grading of the scrap. Thus auto inner tubes are universally made of good rubber compounds and they sell in car-load lots for 26 cents per pound at a time when garden hose sells for 2 cents per lb., rubber heels, 3 cents; bicycle tires, 4 cents; airbrake hose, 5 cents; untrimmed arctic gum shoes, 6 cents; auto tire treads, 9 cents; and good red scrap 10 cents per pound.

2. *Reclaimed Rubber.*—Scrap rubber which has been freed from cotton or other textile fibers and put in a plastic condition. This may be accomplished by grinding up the rubber with oils; by heating the mixture of rubber and vegetable oil in an autoclave; by treating the rubber with caustic alkalis under pressure. The object in all cases being to remove as far as possible the sulfur which has been combined with the rubber.

3. *Alkali Reclaimed Rubber.*—Heating with dilute caustic alkalis is generally acknowledged to be the best known process for removing the sulfur from vulcanized rubber compounds. It is covered by a patent to Marks, No. 635,141, granted October, 1899.

4. *High-Grade Reclaimed Rubber.*—This term is preferably limited to reclaimed rubbers containing not less than 50 per cent of rubber substance. In view of the numerous sources from which the scrap rubber is obtained it is recommended that contracts for this material be accompanied by a statement showing specific gravity, non-volatile mineral matter, organic aceton soluble matter, free sulfur, total lead calculated as PbO. In the case of red reclaimed rubber the analysis should show the percentage of total antimony calculated as antimony pentasulfide. Most red stocks used in auto tires owe their color to red oxide of iron, and in recent years the red color of druggists' sundries has frequently been produced by means of organic dye lakes.

5. *Floating Reclaimed Rubber.*—This term is preferably limited to reclaimed rubber of specific gravity of 1.100 or less; free sulfur, not more than 0.05 per cent; rubber content, not less than 90.0 per cent; total sulfur, not more than 5.0 per cent.

6. *White Substitute.*—Elastic products prepared by the action of sulfur chloride on vegetable oils. If they contain more than 1.0 per cent of "non-volatile mineral matter" they are classed as adulterated. Specifications for this material should state the amount of "aceton-soluble matter."

7. *Brown Substitute.*—Elastic products prepared by the action of sulfur on vegetable oils. Specifications should state the amount of free sulfur and the amount of organic aceton-soluble matter.

8. *Rubber Resins.*—Substances occurring in all natural rubbers. They appear to be a form of oxidized rubber, soluble in aceton. Pontianak, Balata, Gutta percha and Chicle are especially rich and usually contain more than 50.0 per cent resinous matter.

9. *Pitch Hydrocarbon.*—This term is preferred to "mineral rubber" for the various pitch products prepared from asphalt, coal tar, petroleum, and stearin. It should be noted that petroleum pitch and the natural bitumens contain unsaturated compounds and these materials are therefore capable of absorbing a certain amount of sulphur. This is not equally true of coal tar pitch. Stearin pitch on the other hand contains a certain amount of saponifiable matter. The word "mineral rubber" although frequently used in the trade is misleading, and should be abandoned.

GROUP 3. FACTORY TERMS

1. *Green Stock.*—Washed and dried rubber which has been mixed with fillers and vulcanizing agents, but has not been vulcanized.

2. *Rubber Cement.*—A rubber compound which has been suspended in a volatile organic solvent such as benzine, benzol, or carbon tetrachloride. Some cements are made up with the vulcanizing agent and are sold in the form of a plastic mass for filling cracks in automobile tires. In other cases the cement is spread on a surface and the sulphur chloride is applied to the cement after the solvent has evaporated.

3. *Vulcanized Rubber.*—A rubber compound which has been subjected to the action of heat while under pressure in order to effect a chemical union of the sulphur with the rubber substance. The characteristics of vulcanized rubber are tensile strength and elasticity, both of which are absent in the green stock.

4. *Backing.*—This term is encountered in specifications for cotton rubber-lined fire hose. It is the thin sheet or layer of calendered rubber compound which is applied to the outside of the rubber tube, before the tube is pulled into the cotton jacket. The backing being of a softer compound, helps to bind the tube firmly to the jacket.

5. *Friction.*—A rubber compound applied to a cotton fabric in a thin layer by means of a friction calender. In this operation all the interstices of the fabric are filled with the rubber compound and the coated fabric so produced can be readily vulcanized to another piece similarly treated—or can be vulcanized to a surface of rubber compound. The word "friction" should not be used as a synonym for "adhesion."

6. *Skim Ply.*—A thin layer of rubber compound applied to cotton duck which has already been coated with "friction." This is done for the purpose of protecting the cotton fabric thoroughly (as in the case of rubber belting) or for the purpose of providing an especially rich compound to serve as a binder between two surfaces.

7. *Cushion.*—In automobile tires, a special ply of rubber compound placed between the breaker strip and the body of the tire. This serves to bind the tread of the tire firmly to the body of the tire (the layers of cotton duck).

8. *Bead.*—A solid, tough rim or edge extending around both edges of an auto tire and used for keeping the tire firmly in position after it has been sprung on the tire rim.

9. *Tread.*—That portion of an auto casing (automobile tire) which bears directly on the highway when the tire is placed on an automobile ready for use. The rubber compounds used for the tread are preferably tough and of great tensile strength, and firmly attached to the body of the tire.

GROUP 4. SCIENTIFIC TERMS

Rubber.—A hydrocarbon of the empirical formula $(C_{10}H_{16})_n$ contained in the latex of certain milk-bearing plants and separated from this by coagulation. When used in specifications, the word "rubber" is held to mean "washed and dried rubber," as it is found in rubber goods factories just previous to the compounding operation. It includes the natural resins, proteids, mineral matter and the rubber hydrocarbon itself. Rubber is characterized by its limited solubility in certain organic solvents; its ability to combine with sulphur in the proportion of approximately 100:7 to form a product of considerable tensile strength and elasticity; its specific gravity of less than 0.990. Rubber is also recognized by the formation of Nitrosites when treated with nitrous acid vapors.

Rubber Hydrocarbon.—This term is held to mean washed and dried rubber which has been freed from the natural rubber resins, proteids and mineral matter. It is contained in the latex of certain milk-bearing plants. In 1905 Professor Harries (University of Kiel) described it as a highly polymerized 1-5-dimethyl-cyclo-octadien.

Synthetic Rubber.—Isoprene polymerized to a rubber-like substance having the same empirical formula as the natural rubber hydrocarbon.

GROUP 5. GUMS RELATED TO RUBBER

Balata.—A gum prepared by coagulation from the milk of *Mimusops globosa.* It is imported from Guiana and Venezuela in the form of blocks or sheets. The principal uses for the gum are in the manufacture of "balata belting" for power transmission and in the manufacture of dress shields.

Chicle.—A gum prepared by heat-coagulation from the milk of *Achras sapota.* This tree grows principally in Yucatan and the gum is exported in blocks from Tuxpam, Belize, Panama and other nearby ports. As imported into the United States it contains approximately 40 per cent water and the dry gum shows approxi-

mately 60 per cent resins. It is used exclusively for the manufacture of chewing gum, of which it forms about 25 per cent; the retail market price of chewing gum at this time is $1.30 per pound.

Guttapercha.—A gum prepared from the milk of *Palaquium gutta,* a tree found in the Islands of the Malay Archipelago. It is frequently adulterated with resins, and in other cases balata is sold as gutta percha. The principal difference between these two gums lies in their physical properties so that it is difficult to distinguish between them by mere chemical tests. Extensive experience in handling gums is the only reliable way for arriving at the value of the crude material. Guttapercha is used by dentists for temporary fillings; for the manufacture of dress shields; for the manufacture of waterproof coverings for submarine cables.

Guayule.—A gum prepared from the herbaceous plant, *Parthenium argentatum,* found on the plateaus of Mexico. It is separated by macerating the stalks with warm water and subsequently floating off the agglomerated particles of gum. The dry gum shows about 20.0 per cent aceton-soluble matter (resins).

Pontianak.—A gum prepared from the milk of *Dyera costulata* and related species in Borneo and Sumatra. The latex is coagulated by means of kerosene together with acidic salts (such as alum). This gum is known in England as Jelutong, but here it is universally sold as Pontianak, the name of the port on the island of Borneo from which it is shipped. The dried gum contains about 75 per cent resins, a fact which makes it of especial value for the preparation of "friction" compounds in the manufacture of mechanical rubber goods.

Assam.—A gum prepared from *Ficus elastica* in Burmah and India. Attempts have been made to cultivate these trees, but the difficulty lies in the fact that the milk coagulates so rapidly that it is impossible to collect large quantities of the milk for central coagulation.

Caucho Ball.—This gum is prepared from the *Castilloa elastica* and related species which grow in the Amazon Valley. This rubber is not coagulated by smoke. It occurs in commerce as "upper caucho ball" and "lower caucho ball," both of which are inferior to Hevea rubber. When washed and dried the "upper" loses 20 to 25 per cent and the "lower" loses from 37 to 40 per cent of its weight.

Castilloa Rubber.—This is obtained in Mexico from *Castilloa elastica.* It should not be confused with the Caucho Ball shipped from Brazil.

Manicoba Rubber.—This gum is prepared from *Manihot Glaziovii* and *M. dichotoma* and is shipped from the province of Ceara in Brazil. Since 1910 this rubber has become popular in America for the manufacture of high-grade products.

Mangabeira Rubber.—This gum is prepared from *Hancornia speciosa* and is shipped from Bahia and Pernambuco in Brazil.

African Rubber.—The principal "Africans" which are offered on the American market are in the order of their value: (1) Lopori, (2) Upper Congo, (3) Rio Nunez, (4) Conakry, (5) Massai, (6) Soudan, (7) Kamerun, (8) Benguela, (9) Accra. All these rubbers are obtained from various species of *Landolphia* and are therefore sometimes designated "vine rubbers." Accra rubber is also obtained from *Funtumia* and from *Clitandra;* while the rubber from the German colony of Sud Kamerun is obtained principally from *Funtumia* plants.

When purchasing these rubbers, the buyer judges them mostly by weight and general appearance. If they are dirty and full of sand, they will be obviously heavy. The loss on washing and drying these rubbers is considerable. Accra lumps may lose from 40 to 50 per cent

of their weight. On the other hand Upper Congo Balls may lose only 15 per cent of their weight. The price then varies from 25c. to 65c. (January, 1917).

GROUP 6.   TERMS USED IN FOREIGN COUNTRIES

Plantation Para is the English term for plantation Hevea rubber.

Fine hard cure Para is the English term for up-river fina Para rubber.

India rubber: an obsolete term for rubber.

Caoutchouc: the French term for rubber.

Borracha: the Portugese term for rubber.

Seringueira: the Brazilian name for the *Hevea* tree.

Seringueiro: the Brazilian term for the man who gathers *Hevea* latex.

Latex (Brazilian): the milk juice of certain tropical plants which yield rubber.

Seringal: the forest where the *Hevea* trees grow.

Caucheiro (Brazilian): a collector of *castilloa* latex.

Chicleiro (Brazilian): a collector of chicle latex.

Urukuri nuts (Brazilian): the nuts obtained from the *Attalea excelsa* plant in Brazil and used there for "smoking" or coagulating the latex of *Hevea brasiliensis*.

The Rubber Trade Laboratory.
  Department of Legal and Official Chemistry,
    Newark, N. J.

Electrolytic Equivalents of Gases
By Carl Hering

For calculating the amounts of gases set free by electrolysis by means of Faraday's law, the textbooks usually give the constants in terms of their weights, as that law is based on the chemical equivalents and these are in turn based on weights. Moreover for many purposes the weight of a gas (in effect, its mass) is the simplest and most rational way of specifying a given quantity of it, for when thus stated the quantity is independent of the pressure and temperature which become such disturbing factors whenever the quantity of a gas is stated in terms of its volume.

It often happens in practice, however, that one wants to know the quantities of electrolytic gases in terms of their volume, and with the usual electrochemical equivalents it is then necessary to make an additional calculation for which one requires additional physical constants; the textbooks often do not give these in their most convenient form, thereby involving still further calculations, and the reference books which give these data are not always readily available. Moreover Faraday's law, when stated physically instead of chemically, that is, when applied to the volumes of gases instead of to their chemical weights, becomes very much simpler for gases, as both the chemical weights and the densities then fall out of the calculation with the result that the physical constant which is involved then becomes the same for all gases (with some restrictions) hence no longer requires a table of values for the different gases. The purpose of this article is to give these constants in their simplest form and based on the best known fundamental data.

The latest, best and internationally accepted value of the fundamental electrochemical equivalent is that of silver, namely 0.00111800 gram per coulomb, and the internationally accepted value of the atomic weight of silver for 1917, is 107.88; both have been officially accepted by the Bureau of Standards.

From these two basic constants Faraday's law may be most conveniently formulated for calculations in practice, in the following terms:

The quantity of any element which undergoes electrolysis is *by weight* and for a change of valency of unity, equal to:

Atomic weight $\times$ 0.010363, in milligrams per coulomb.

Atomic weight $\times$ 0.037308, in grams per ampere-hour.

Atomic weight $\times$ 0.082250, in pounds per 1000 ampere hours.

The reciprocals of these standard values are:

96.494 $\div$ atomic weight, in coulombs per milligram.

26.804 $\div$ atomic weight, in ampere-hours per gram.

12.158 $\div$ atomic weight, in ampere-hours per pound.

The physical meaning of these constants is that they would be the actual values for a hypothetical element having an atomic weight of exactly unity. As the atomic weight of hydrogen is 1.008 they represent that gas to within a little less than 1 per cent.

These apply to all the elements. They are, however, only for a change of valence of unity, hence for any other these constants of the first group must be divided by that change of valence, or those of the second group (the reciprocals) multiplied by it. It takes a certain definite quantity of electricity (96,494 coulombs) to make or break each chemical bond in electrolysis, and when there are two such bonds, that is when the valence is 2, it of course takes twice as much electricity, hence the quantity of material electrolyzed by a given quantity of electricity (as in the first group of the above formulas) will be half as great. Thus for oxygen gas for instance the above constants of the first group must be divided by 2, or those of the second multiplied by 2, as the change of valence for oxygen is almost always 2.

The writer is using the term "change of valence" instead of merely "valence" as used in most books, because the latter term alone may sometimes lead to very incorrect results, as it is not always the valence which an element has in a chemical compound which governs the electrolytic quantities, but it is always the *change* of valence during electrolysis which is the true governing factor, that is, the *difference* between the valences before and after electrolysis.

The valence of any element in its free, uncombined state is, of course, zero, because the term valence, in Faraday's law at least, means the number of bonds per atom which combine it with another element, and when not combined these bonds of course do not exist. Hence when in electrolysis an element is set free it means that it has changed its valence, from what it had in the compound, to zero; in that specific case therefore, and only in that case, is the "valence" numerically equal to the "change of valence" and it is only this particular case, and not the more general case, that the textbooks refer to when they give Faraday's law in terms of "valence" instead of more broadly and more correctly in terms of the "change of valence."

As an illustration, ferrous sulphate is oxidized (or adduced) at the anode to ferric sulphate; nothing is set free. The valence of the iron in the former is 2 and in the latter 3, the *change* of valence is therefore 1; the electrolytic oxidation has increased the valence by 1; oxidation always means an increase of valence or an addition to it, hence the proposed new and broader term "adduction"*; the physically opposite to oxidation is a chemical reduction which always means a reduction of the valence. The quantitative electrochemical calculations of the amount of ferrous sulphate oxidized by a given current, must therefore be based on a change of valence of 1 and not on the actual valences 2 or 3, which latter would naturally give greatly incorrect results.

The increase and decrease of valences corresponding to oxidation and reduction necessarily mean that valences may be negative also, and that therefore a change from, say, —2 to zero (as in the setting free of

*See this Journal, December 1, 1916, page 649.

oxygen) is an increase of valence. Bonds which represent a positive valence for one element are negative with respect to the other to which they bind it. The number of positive and negative valences in a compound must always add up to zero.

The above constants refer to the weights of the elements involved, and these weights per coulomb are different for each of the elements on account of their difference in atomic weights. When they are gases however, Faraday's law becomes much simpler if the amounts are stated by volume instead of by weight, as the atomic weights and the densities of the gases then drop out of the calculation, the physical constant then being (with certain restrictions) the same for all the gaseous elements. This is a consequence of a combination of Faraday's law with Avogadro's law, the latter being in effect that in their gaseous state a gram molecule of any element occupies the same volume, which for 0 deg. C. and 760 mm. is equal to 22.390 liters.

It is very necessary in this law to know how many atoms there are in a molecule of the particular element. But as the present article deals only with the six gaseous elements which are or may be set free electrolytically, at ordinary temperatures and pressures, namely bromine, chlorine, fluorine, hydrogen, nitrogen and oxygen, it will suffice for the present purposes that in all these elements the molecule is considered to have two atoms, that is, they are diatomic. But whether this is a mere theoretical conception or not, or whether it is correct or not, does not matter in what follows, as it can easily be shown from the above formulas and the densities of the gases that the simpler and more direct formulas given below give the correct results. Attention, however, is here called to the fact that this molecular structure of some of the gases applies only to the ordinary temperatures, because at very high temperatures chlorine, bromine, and probably fluorine, are said to change over to one atom per molecule, becoming monatomic.

With the above limitations, the combination of the laws of Faraday and Avogadro, and the above standard constants, give the following simple formulas applicable to the six elementary gases, bromine, chlorine, fluorine, hydrogen, nitrogen, and oxygen, at ordinary temperatures:

The quantities of any of these gases set free by electrolysis, at 0 deg. and 760 mm., are *by volume* and for a change of valence of unity, equal to:

0.11602 cubic centimeter per coulomb;

0.41767 liter per ampere-hour;

14.750 cubic feet per 1000 ampere-hours.

The reciprocals of these standard values are:

8.6193 coulombs per cubic centimeter;

2.3943 ampere-hours per liter;

67.798 ampere-hours per cubic foot.

As with the former groups, these values apply only for a change of valence of unity, and for any other those of the first group must be divided by that change of valence, or those of the second group (the reciprocals) multiplied by it. Thus 1000 ampere-hours will set free 1000×0.4177 liters of hydrogen whose change of valence in all ordinary cases is always 1; but only half as much oxygen will be set free because its change of valence in all ordinary cases is always 2.

The basic constant involved in the above may be more easily remembered by the fact that at about 50 deg. C. (accurately 53.82 deg.), that is, at about half way between the temperature of freezing and boiling water, or a little above blood heat, or about as hot as our hands can stand, the constant for these diatomic gases (at the normal pressure of 760 mm.) is equal to just 2 ampere-

hours per liter, hence a little more than two for room temperatures.

The equivalence between the quantity of electricity and the volume of the elements when in the form of gases or vapors, instead of their weights, may be termed the electrophysical equivalent as distinguished from the more usual electrochemical equivalents, as it is independent of the atomic weights. It may be said to be the fundamental or basic law, and that Faraday's law as usually stated is a deduction from it or a corollary It applies strictly, however, only to perfect or ideal gases; it seems that the gaseous elements do not all behave like perfect gases, but the differences are slight, being apparently of the order of fractions of a per cent, hence can be neglected for all practical purposes.

Unusual cases might perhaps arise in which a gas in a higher combination is first reduced by the current to a lower valence and then set free. The above figures will, however, still give the correct results if the change of valence used is the total change from the original to the final (zero).

The above values are for 0 deg. and 760 mm. barometric pressure. The correction for any other atmospheric pressure would probably be negligibly small, but it is easily made by remembering that the volumes are inversely as the pressures, or roughly by percentages. Thus for 768 mm. the volume would be about 1 per cent less.

For the temperature correction it need only be remembered that the volume increases 1/273 for each centigrade degree, or at the rate of 1 per cent for each 2.73 deg. C.; or for the Fahrenheit scale 1 per cent in volume for each 4.91 deg.

Philadelphia, Pa.

Mississippi Centennial Exposition.—Mississippi is to have a centennial exposition beginning Dec. 10, 1917, at Gulfport, on the Gulf of Mexico, and lasting about six months. A large force of men is at work on the foundations of seven of the buildings. These will be permanent, and include a coliseum to seat 5000 and the Mississippi State Building. Nearly all the other Southern States will have buildings. It will be the first large exposition to be held in the South for thirty years. The Government will have a $750,000 exhibit.

American Dyestuff Industry Discussed at Textile Club Banquet.—The semi-annual banquet of the Textile Club was held at the Hotel Martinique on March 3. Several speeches were made on the progress of the manufacture of dyes in this country. Dr. B. C. Hesse spoke on "The Coal-Tar Industry and Preparedness," Dr. Thomas H. Norton spoke on "Is Germany's Primacy Assured?" and I. F. Stone spoke on "The American Dyestuff Industry." Dr. Charles H. Herty, Mr. William McComb and Dr. Herman A. Metz also delivered addresses. Dr. Hesse laid particular stress on the necessity of making our tariff really protective instead of leaving a loophole in it as it exists at present. Dr. Norton estimated that by 1920, at the present rate of expansion, we should be making the great bulk of the staple synthetic colors required by our industries. Mr. Stone said that the dyestuff industry here is on a permanent basis, for the reasons that we have all the primary coal-tar derivatives, such as benzol-naphthalene, etc., which are required, we have made a start at protecting the industry and the consumers realize the need of having our own industry. Besides this the manufacturers, owing to the abnormal conditions, have been able to make a good profit and to write off their plants and lay aside funds for research, increased capacity, etc., and are consequently in a strong financial position, and will be able to meet competition.

The Cementation of Iron and Steel

By Ernest Edgar Thum, E. M.

Assistant Professor of Metallurgy, University of Cincinnati.

Dr. Federico Giolitti, probably the greatest authority on cementation, has recently issued a very important book[1] on this subject, in which he analyzes and collects all the important work so far available. In the opening sections of the volume he summarizes the published data having a bearing on this matter which has appeared in the last sixty or seventy years, starting with the earliest work and the earliest theories. He then presents the work which has been done in his own laboratory during the last ten years, showing how his results have clarified many perplexing aspects of the situation. Lastly, he gives a very clear and full account of the various furnaces and methods employed in well equipped modern plants for the very important process of case hardening.

Dr. Giolitti's most excellent book suffers the inevitable defect of logical discontinuity which is bound to result in a compilation built upon a historical review of the development of praxis and theory. Such a method must result in considerable repetition of subject matter. Then, too, the discussion of the errors of the early experimenters which fills the opening sections presupposes familiarity with the most modern ideas of the subject upon the part of the reader. This, unfortunately, even but few metallurgists possess, nor will they acquire until they have read the book at least once. A second reading in this case is not particularly inviting, as unfortunately the English translation is much deficient in elegance—the style being very tiresome, involved and at times obscure.

"Cementation processes" include those which enrich the surface of wrought iron or low-carbon steel to various depths by the addition of cementite, (Fe_3C), that carbide which is responsible for the variation in the physical properties of soft irons and hard steels. The method consists of heating a carbonaceous substance in close contact with the iron to be carburized in a suitable container. From the iron-carbon equilibrium diagram it is evident that Ac_1 (690 deg. +) is the minimum temperature at which true cementation can proceed; graphitic carbon will diffuse into iron at lower temperatures than this by reason of the forces due to the difference in concentration, and if it does combine with the iron the carbide produced cannot enter into solid solution until Ac_1 is exceeded. Otherwise the properties of a more highly carburized true steel are lacking—the added cementite does not form increasingly large masses of pearlite, but remains as a fine meshwork of free crystals where it was formed. If 690 deg. C. is the minimum temperature for cementation, as a maximum limit the steel must be kept from "burning" during the carbonizing process—that is to say, below the point of incipient fusion of the austenite of the carburized muff. The rate of carbon absorption of liquid austenite is enormously higher than that of the solid solution, and the result will be a zone so high in carbon as to be a true cast iron. In short, true cementation proceeds only at temperatures and carbon concentrations bounded by the area where austenite (the solid solution of gamma iron and iron carbide) is stable, as delineated in the iron-carbon equilibrium diagram.

Total Carburization for Blister Steel

Apparently, the most obvious variation in cemented metal is the depth to which the carburization extends.

[1] The Cementation of Iron and Steel, by Dr. Federico Giolitti, Professor in the Royal Polytechnic of Turin. Translated from the Italian by Joseph W. Richards and Charles A. Rouiller. Copyright 1914. New York: McGraw-Hill Book Co., 1915.

On this basis has grown a distinction between "total" cementation, where the piece is intended to be wholly transformed into a high carbon steel, and "partial" cementation, where the process is frankly limited to the production of a thin, hard case overlying the original low carbon tough material. As a matter of fact, the term "total" cementation is a misnomer, inasmuch as the process is seldom if ever continued to a time when there is a considerable increase in the carbonization at the very axis of the metal. The reason for this is evident upon reflection. The transference of carbon from without to within is caused by diffusion forces set up by the difference of carbon concentration at these points. We might expect that after a considerable time approximate equilibrium could be attained at the exterior of the piece, but that a continually decreasing carbon content would attend the deepest regions. When equilibrium at the center is approached, the difference in carbon concentration, edge to center, is so small and the consequent rate of diffusion so slow that the time necessary for total cementation of even small bars would be so great as to be absolutely prohibitive.

Deeply cemented bars are often forged directly into springs; or, after faggoting and rolling, into cutlery;
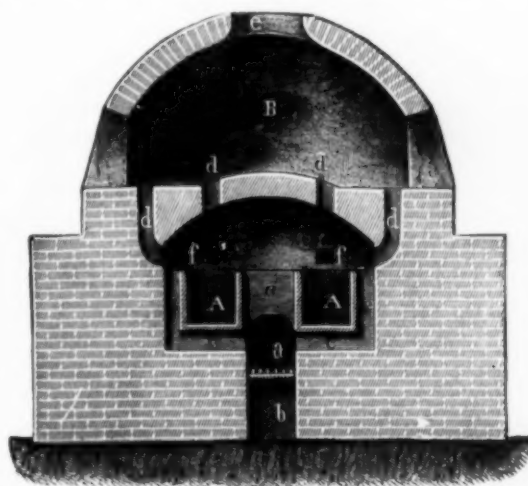
FIG. 1—CROSS SECTION OF CEMENTATION FURNACE

but preferably are first melted in crucibles to equalize their carbon content. Indeed, total cementation was the main source of steel up to Bessemer's discovery, and to-day survives as the producer of the highest grade of carbon-steel tools. The methods and furnaces used are exactly the same to-day as when the industry flourished a century ago, innumerable variations in practice having been tried and discarded meanwhile.

Fig. 1 (Fig. 73 from Giolitti) shows a cross section of the furnace used for total carburization. A pair of tight rectangular boxes of refractory brick some three by three feet in cross section and eight to fifteen feet long are built on either side of a long fireplace and enclosed in a massive masonry furnace-setting. Special provisions for uniform heating are made, such as a series of flues for the flames to play on all sides of the box and a double arched dome over the laboratory. Flat bars of the purest wrought iron are packed into these boxes, each bar entirely surrounded by a layer of crushed charcoal at least three-quarters of an inch thick, and the loaded box sealed by a layer of wheelswarf. When all is ready, coal fires bring the temperature of the furnace up to 1100 deg. C. in the course of two days, at which temperature it is kept as nearly constant and uniform as skill will permit until such a

time as the fracture of a "spy" withdrawn from the box indicates that the cementation has proceeded sufficiently. This requires a matter of from seven to eleven days, varying as the furnace conditions, cement in use, and the desired percentage of carbon. Cooling to a temperature low enough to enter the furnace setting and unloading it requires a matter of another week. The surface of the bars has now lost its metallic appearance and has acquired a dull brown, blistered surface. Each bar of this "blister steel" is then broken and classified according to its mean carbon content, as judged by the appearance of the fracture, when it is melted in the crucible, rolled or forged.

It is claimed that crucible steel made in this manner is superior to any other modern ferrous product. This, if true, is possibly due to the fact that the purity of the superlative wrought iron used in the cementation boxes is in no way vitiated by the subsequent process—indeed, the fusion serves to eliminate the remnants of mechanically entrapped slag. The cementation material regarded as the surest and best for this process is the result of centuries of experience with hundreds of mixtures and is simply crushed charcoal (2 to 15 mm.). The mixture of other solids into the cement serves no useful purpose whatever, for it is liable to add something as an impurity to the finished product. The result of melting cemented bars in the crucible is a high-carbon steel lower in silicon and manganese than that attainable in other processes without running the danger of oxidized and brittle products. Lately, the difficulty of getting a properly "killed" crucible fusion has led to the use of ferro-alloy deoxidizers which may increase the silicon or manganese content up to a point where such crucible steel is hard to distinguish either chemically or mechanically from a well-made electric furnace product.

The early observed fact that low-carbon steel bars do not blister in the cementation furnace while wrought-iron bars show this surface defect makes it appear likely that the slag is responsible for the occurrence of the blisters, inasmuch as the presence of particles of slag in the wrought iron is the prime difference in constitution of these two materials. In 1864 Percy proposed the most probable explanation: that the slag, consisting of basic ferrous silicates, was decomposed or reduced by the carburizing agent with the local production of a larger quantity of gas than could diffuse readily, the excess of which broke through the hot plastic metal and produced the characteristic markings.

Partial Carburization of Machine Parts

An enormous amount of experimental work has been done in an effort to elucidate thoroughly the mechanism of the carbonizing reactions which go forward during cementation, leading to various theories backed by as many ardent supporters. The whole matter has been reviewed and clarified by the experimental work conducted in Dr. Giolitti's laboratory, now summarized in his recent volume. This work would have been of minor practical importance were it not applicable to the process of

"partial" cementation. Though the manufacture of blister steel may be on the decline due to the sharp competition of high-grade electric furnace products, the advances in machine design call for an increasingly large number of parts which are hard enough to resist wear or abrasion, and yet tough enough to withstand shock and "fatigue." In all steels except some very expensive alloys, it is well known that a high hardness numeral is had at the expense of ductility, but the combination of these desirable but mutually contradictory qualities may happily be had by transforming the outer surface of a tough low-carbon piece into a hard high-carbon steel. Again, case hardening operations are the favorite method of producing cheap metallic pieces for taking a high polish. Or, lastly, the ends of such articles as axles may be carburized for bearings, while the rest of the bar can be entirely protected from the action of the cement.

The methods for this most important operation are various, depending first of all upon the cement used, whether solid, liquid, gaseous, or some combination of these three. As a matter of fact, a large percentage of the case-carburizing is done in a manner very similar to that of "total" cementation described above; that is, by packing the pieces in crushed charcoal in closed metallic boxes and then heating the box and contents. The size of heating furnace naturally varies with the shape and size of the metallic articles to be treated and the fuel used, and may range from the large coal-fired setting shown in cross section in Fig. 2 (Fig. 79 of Giolitti's book) to the small gas or oil-fired muffle type of Fig. 3 (Fig. 97 of Giolitti's book). In any case, it should conform to these general requirements: At the start of operations it should be capable of quick and uniform heating up to 1200 deg. C. During cementation the temperature at all points of the carburizing box or muffle should be held constant and uniform at any temperature between 850 deg. and 1100 deg. C., at the option of the operator, with a tolerance of from ten to thirty degrees. This requirement demands a tight
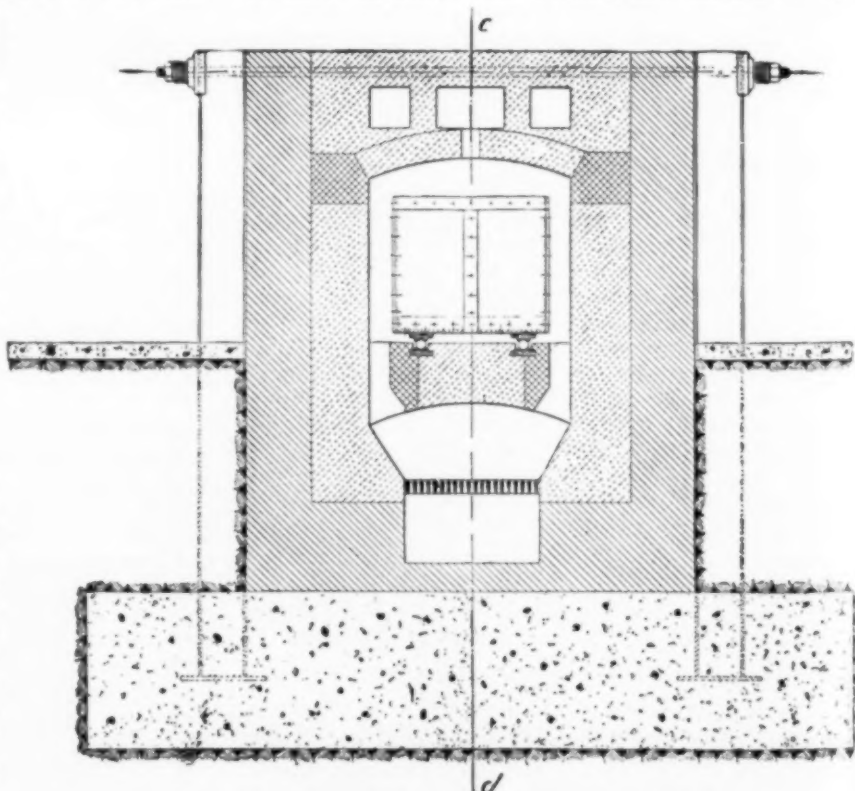

FIG. 2—CROSS SECTION OF LARGE COAL-FIRED FURNACE FOR CEMENTATION IN BOXES

setting, with heat-insulated charging doors of the lift type which can be clamped shut, and almost excludes the use of intermittent coal-fired grates. In order that the muffle or box containing the metallic pieces and the cement may not be rapidly destroyed, a neutral or reducing atmosphere should be maintained. Peep holes and pyrometer openings must be provided. Rollers, balls, or even cars, are provided to expedite the entrance and removal of the larger carburizing boxes, while economy of fuel and furnace maintenance demands continuous operation. The boxes themselves should have a tight cover which can be luted shut, and be as small as is consistent with the requirement that it must allow at least one inch of carburizer on all sides of the pieces. As will be seen, it is always necessary to pay particular attention to obtaining a close contact between solid carburizers and the metal.

Of the many kinds of carbonaceous materials used as cements, we will confine our attention at the outset to crushed wood charcoal, remembering that the mechanism of the action during "partial" or "total" cementation is identical, the sole difference being the amount of carbon absorbed by the metal—therefore a quantitative variation only.

The Diffusion of Carbon Into Iron

A superficial survey of the conditions existing in the cementation box would indicate that the carburizing action could be most readily explained by supposing that the carbon of the cement (charcoal being nearly pure carbon) merely diffuses as such into the carbon-poor iron. Doubt is thrown upon this view when it is learned that charcoal, as a cement, is rapidly "exhausted"; that is to say, its efficiency is continuously impaired upon re-use. The temperature of the process has by no means been high enough to graphitize or otherwise change the physical state of any considerable percentage of the charcoal carbon, and the view has been repeatedly advanced[2] that "solid carbon outside of a fragment of steel cannot penetrate into it without the intervention of a gaseous vehicle." However, Roberts-Austin[3] heated in a vacuum previously ignited electrolytic iron in contact with diamond and obtained carburization. Giolitti (text, page 119) shows that the discrepancy in view is due to the fact that *actual physical contact* of the iron and the carbon is the prime requisite of solid diffusion. When this requirement is fulfilled, a three and one-half hour cementation in pulverized carbon at 1000 deg. C. will increase the pearlitic areas very slightly to a depth of 0.15 mm., while any portion more than this fraction of a millimeter distant from a carbon contact will be absolutely unaltered. In the practice of cementation when working with granular material ranging from two to fifteen millimeters in size, the continuous, deep zone of much higher carbon content resulting from a three and one-half hour cementation at 1000 deg. C. must evidently be due to some other cause than direct diffusion of solid carbon.

The first researches on the mechanism of cementation were undertaken to demonstrate that volatile alkaline cyanides were the true cause of the process, acting as carriers of the carbon into the iron. The earlier investigators thought that the alkaline ash of the charcoal reacted with the nitrogen of the air occluded in the pores of the charcoal, together with that remaining in the cementation box, forming the volatile cyanide required by their hypothesis. The "exhaustion" of the cement could then be ascribed to the volatilization of the alkalies in the charcoal ash.

It is unquestioned that the cyanogen radical has an intense carburizing action on steels at high tempera-

tures, but the amount of it existing in the ordinary cementation box packed with wood charcoal approaches zero—is so small as to escape detection by analytical methods. It has also been shown[1] that charcoal which had previously been heated with chlorine gas to the elimination of the last traces of alkalies could be used as a cement in a nitrogen-free atmosphere, and give precisely the same results as were ascribed to the action of the cyanides.

Further, Giolitti (text, page 121) shows that a four-hour cementation at 1000 deg. C. with alkali-free charcoal in an atmosphere of pure nitrogen would produce a case containing a slight increase of pearlitic area at the edge—gaining about 0.20 per cent carbon at this point—the carburized zone decreasing in carbon content at a uniform rate to a depth of 1.8 mm., the maximum penetration of the carbon. This action appears to rest upon the equilibrium conditions of the little-studied system (N: C: CN: Austenite). In the case of carburization with charcoal, its effect is certainly very small. In a similar manner it has been shown that any hydrocarbons which may remain undecomposed in the

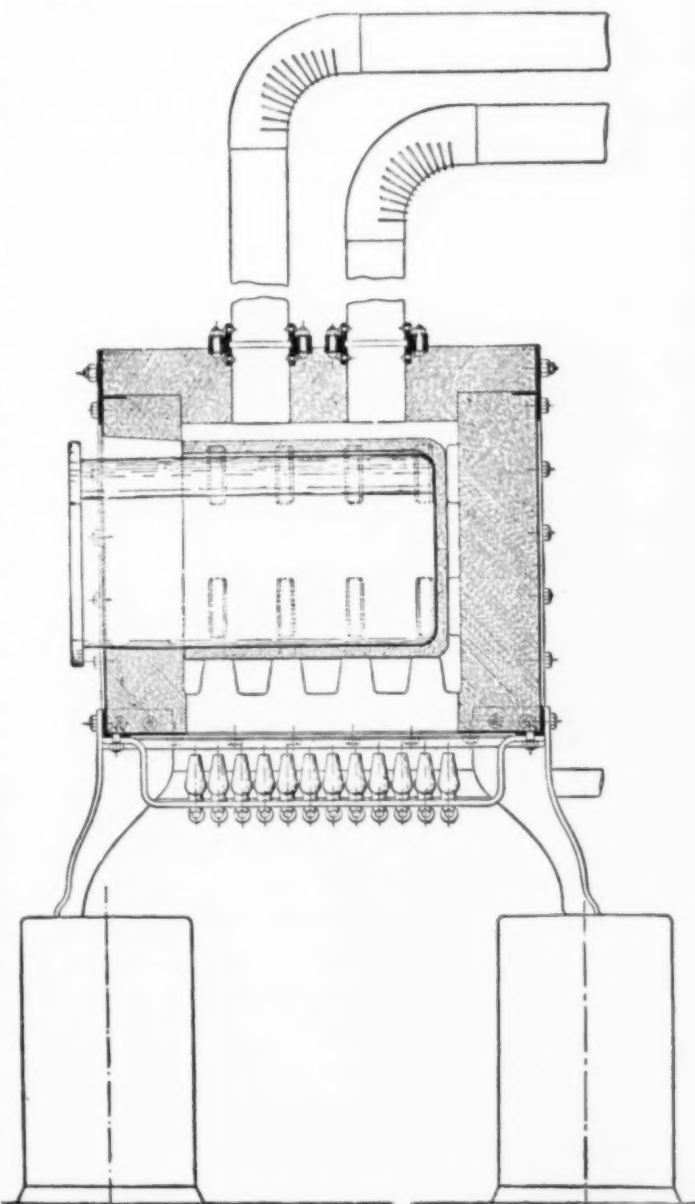[1]Charpy, VI. Revue de Metallurgie, 505 (May, 1909).

FIG. 3—LONGITUDINAL SECTION OF GAS-BURNING MUFFLE FOR CEMENTATION IN BOXES

[2]Charpy and Bonnert, CL Comptes Rendus 173 (Jan. 17, 1910).
[3]1890, I; Journal of the Iron and Steel Institute, 81.

charcoal have a negligible or at least a very small part in the cementation.

Carbon Monoxide the Vehicle of Carbonization

The remaining possibility proves to be the most active carburizer, namely, interaction between the oxygen of the occluded and entrapped air with the incandescent carbon. At the temperature of ordinary cementation (over 1000 deg. C.), the reaction $C + CO_2 \rightleftarrows 2CO$ produces a gas with a very low percentage of carbon dioxide. This gas (particularly carbon monoxide) easily and rapidly diffuses into and reacts with the hot iron, forming iron carbide, which is immediately absorbed into the solid solution austenite. The reaction is $2CO + 3 Fe \rightleftarrows Fe_3C + CO_2$. The dioxide formed at this point diffuses outwards to a region of lower concentration more rapidly than inwards, while the monoxide diffusing inward will form more carbide on its way toward the center of the piece of metal, if demanded by the state of the system Austenite:CO:CO$_2$ existing at that particular locality. The carbon dioxide escaping from the steel is immediately regenerated by the excess of hot carbon to a condition represented by the equilibrium of the system $C:CO:CO_2$.

It is clearly seen that carburization will cease when the relative concentration of the gases in the packing, represented by $C: CO: CO_2$, equals that existing in the steel, which is represented by Austenite: $CO: CO_2$, for at that time diffusion of the carburizing gases will halt simply because of lack of head. As a matter of fact, the maximum carbon concentration in a case-hardened article never reaches the theoretical amount thus called for, simply because the process is interrupted long before equilibrium can be established.

It is also apparent that the isobars of the two systems are identical, Fig. 4 (reproduced from Hofman's General Metallurgy, Fig. 184), and that the maximum concentration of the carbon attainable by the use of charcoal as a cement is by no means necessarily equal to that of saturated austenite at that temperature, as defined by the iron-carbon equilibrium diagram.

Solid Cements

Of all the solid cementing materials, wood charcoal is the best, because, first, it is pure, and therefore maintains the purity of the product; and second, it is of simple composition, being practically carbon only, and therefore the carburizing reactions are not complicated by variable and unknown factors. This allows its use

FIG. 4—EQUILIBRIUM CURVE FOR CO$_2$ AND CO WITH C AT DIFFERENT TEMPERATURES

with certainty of control; the results can be predicted with considerable accuracy. The greatest disadvantages are the slow speed of the cement and the phenomenon of "exhaustion," both of which now seem to be due to the limited amount of carbon monoxide formed in the box. Either the expulsion of occluded air, the covering of carbon granules by fusible, tenuous salts of the ash, or a slight change in the state of the carbon, would slow down the speed of the reactions ($C + CO_2 \rightleftarrows 2CO$; $2CO + 3 Fe \rightleftarrows Fe_3C + CO_2$), which correspondingly diminishes the rate of carburization. The ordinary cementation time and temperature for "partial" carbonization—one or two hours at 1000 deg. C.—will furnish cemented zones less than 1 mm. thick with a low maximum carbon content. The maximum concentration of carbon at the external surface, the depth of the case and its uniformity will increase with the time the piece is maintained at elevated temperatures up to about 1.8 per cent attained in the practice of "total" cementation. In every instance, the percentage of carbon decreases without discontinuity from the edge to the lower carbon core at the center of the metal.

In order to increase the speed of the operation, it is necessary to add one-third to one-half unused charcoal at every packing, or, better, to mix into the charcoal in the first place some 40 per cent of powdered BaCO$_3$ (witherite). The latter procedure (recommended by Caron in 1861) is especially valuable in increasing the efficacy of the cement by bringing a large amount of gas to the cementation chamber; thus $BaCO_3 \rightleftarrows BaO + CO_2$; $CO_2 + C \rightleftarrows 2CO$. The first reaction goes to the left at lower temperatures—CO$_2$ being rapidly absorbed upon exposure to the air. Such a combination has the added advantage, therefore, of being inexhaustible; it is largely used today, and all things considered, is the best *solid* cement for "partial" cementation.

Caron's cement is capable of close control and of giving wide range of effects. The characteristics of the cemented zone are exactly the same as for wood charcoal alone, especially in that the distribution of the carbon diminishes continuously from a maximum at the superfices to the unaffected core; indeed, this is the characteristic of all cements whose specific action is primarily due to the presence of carbon monoxide. The speed of the operation varies as the percentage of admixed witherite and the speed of heating the carburizing box up to working temperature; both factors cause the speed of evolution of carbon dioxide to change. The maximum carburization attained in industrial practice will vary between 0.7 per cent for thin (2 mm.) zones formed at 900 deg. C. up to 1.3 per cent for thicker zones formed at 1100 deg. C.

At the best, Caron's cement suffers the disadvantage of all solid cements used in separate packing boxes, which is that the results cannot be predicted with a precision greater than about 70 per cent. This is due primarily to the variations in the rate of heating, caused by differences in the form and dimensions of the furnace, cementation box, and metallic articles; in the arrangement of the pieces in the box; and lastly in the low heat conductivity of the more or less finely ground cement itself. Again, the relative porosity of the charge affects the freedom with which the carbon monoxide gas circulates from place to place. Consequently, the published data regarding the relations between time, temperature, depth, and carbon concentration are at wide variance; especially so because in most cases the time of cementation is given from the time the *outside* of the box reaches the desired temperature. In practice, control of the process is best maintained by withdrawing and examining a hook-ended "spy" through the box covers when the process is
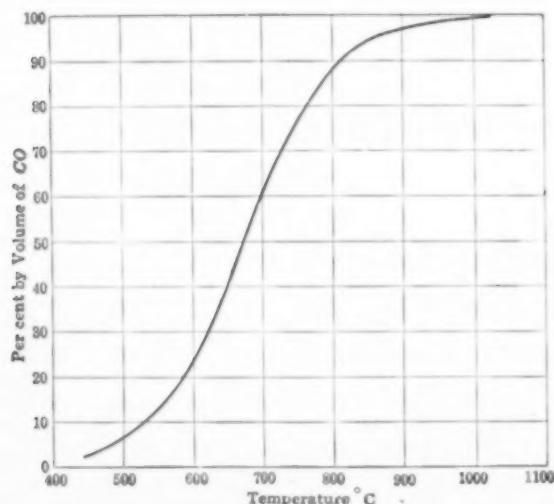
judged to be two-thirds completed, at which time a closer estimate of the necessary additional time may be made.

Innumerable preparations have been recommended and are on the market for use as solid cements, but "there are only some *types* of *simple* cements, at present well known, whose efficacy is a *maximum* from all points of view, and the addition of other ingredients to these typical cements *in no wise increases their efficacy*" (Giolitti, text, page 261). The standard slow cement is Caron's mixture of barium carbonate and charcoal. This may be classed as a "slow" or "gradual" cement, and requires considerable time to produce its deepseated carbonizations. "Rapid" cements are made of various mixtures of sawdust, wood charcoal, bone charcoal, leather, bone, lampblack, tar and heavy hydrocarbons, alkaline and alkaline earth carbonates and cyanides, ferro- and ferri-cyanides; together with homeopathic proportions of numberless other substances, all more or less inert.

Such compounds act by virtue of the large quantity of hydrocarbons or cyanides which are evolved; they exhaust rapidly, give very irregular and non-uniform carbon penetrations with a rapid discontinuous rise from the non-cemented core to thin, excessively high-carbon concentrations at the outside. The variable quantities of complex gaseous mixtures evolved in the cementation box preclude even a moderately close control of the process and result in a non-uniform product containing a hard, brittle case badly addicted to exfoliation. In cementation as well as other processes the simplest combinations are managed with difficulty, while any such variable and complex mixtures as are produced by the destructive distillation of organic materials are absolutely uncontrollable.

Liquid Cements

The use of a liquid cementing material presents a great many advantages. The temperature of a molten bath is easy to control; it maintains itself uniformly by convection currents; and, coming into intimate contact with all parts of even a most complicated steel article, heats it rapidly with the least danger of warping. The discovery of an ideal cementing liquid is yet in the future, however; some one of the following salts or a combination of them is used at present: alkaline or alkaline earth cyanides, ferro- or ferri-cyanides, alkaline bichromates—all extremely rapid in their carburizing action. These salts are maintained at 850 to 900 deg. C. in a small cast-iron crucible in a gas or oil-fired pot furnace, the whole closely hooded to effectually remove the deadly fumes arising from the melt. The operation of carburizing is done by simply immersing the metallic article into the bath for from three to fifteen minutes, depending upon the bulk of the article and the depth of the case desired.

The chemical reactions have not yet been studied

with precision, but it seems that the $(CN)_2$ in contact with the iron decomposes, yielding carbon, which is absorbed into the surface layers of the metal. The time is so short, however, that the carbide thus formed has little chance to penetrate into the metal, and the result is a very thin zone (0.03 to 0.1 mm.) of hypereutectoid steel. Deeper zones result in very brittle and higher carbon muffs which are quite liable to split off when quenched—i. e., "exfoliate."

Often the piece to be cemented is covered with a dry or pasty mixture of these salts and then carefully heated to above the critical range in a forge until the "carburizing varnish" melts and penetrates, when a quenching follows. As with the liquid bath, the equilibrium conditions of such a process are unknown, but in gamma iron, both give a high carbon concentration in a very thin zone.

Gaseous Cements

During the researches undertaken to elucidate the mechanism of the action of cementation with wood charcoal, a number of carburizations made by heating the steel in a gas current revealed some peculiar advantages. Dr. Giolitti experimented with gases such as carbon monoxide, ethylene, methane, acetylene, and illuminating gas, and grouped them into three classes which he calls Types I, II, and III, according to the characteristics of the cemented zone which they produce. In the investigations, cylindrical pieces of a pure soft steel (0.06 per cent C.) were carburized in an electrically heated tube furnace in a stream of dry gas at various temperatures, pressures and times; at the end the pieces were polished, etched and examined under the microscope, then mounted in a lathe, and successive layers two-tenths of a millimeter thick removed and analyzed.

Cemented zones belonging to Type I are produced by the use of pure carbon monoxide. The appearance of the edge is shown at 75 diameters in Fig. 5 (reproduced from Giolitti, Fig. 27), the carbon concentration of which (as revealed by the analyses of the successive layers turned from the cylinder) is shown in the "concentration-depth" diagram, Fig. 6 (reproduced from Giolitti, Fig. 25). The mechanism of this carburization has been indicated already in the discussion of the action of the solid cements, and the series of experiments with the pure gas proves it to be dependent upon the equilibrium conditions of $CO:CO_2$ as affected by the presence of low carbon austenite.

Mechanism of Action of Carbon Monoxide

Assume conditions as at the commencement of carbonization—we have a low-carbon steel piece at 1000 deg. C. (which we will designate as .06 Austenite) in an atmosphere of carbon monoxide. The carbon monoxide diffuses to regions of low gas concentration—that is to say, into the iron. On entering the metal it comes into molecular contact with .06Austenite, which has a higher "affinity" for the carbon of the gas than has the oxygen, and the reaction (.06Austenite + 200CO → .08Austenite + 196CO + 2CO$_2$) goes forward until equilibrium is established—which for the purposes of this equation we will assume to be with .08Austenite. and $CO:CO_2 = 196:2$.

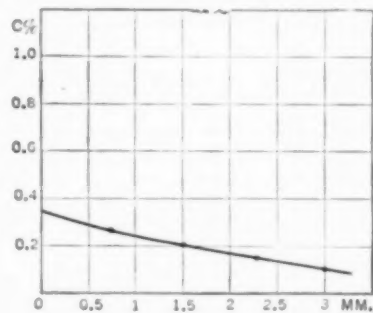FIG. 5—MICROSECTION OF EDGE OF BAR CARBURIZED WITH CARBON MONOXIDE (75X)

FIG. 6 — CONCENTRATION-DEPTH DIAGRAM OF BAR CARBURIZED WITH CARBON MONOXIDE

The gas diffusing inwards is no longer pure CO, but contains some CO_2. It is in equilibrium with .08Austenite, but as it passes inward it comes in contact with fresh .06Austenite. Equilibria are now set up for the new locality, somewhat as follows: .06Austenite + 98CO + 1CO_2 → .07Austenite + 96CO + 2CO_2, continually decreasing the ratio CO:CO_2 as the gas penetrates farther and farther. Finally it is in equilibrium with .06Austenite, when no further carburizing action will take place.

The first "wave" of carbon monoxide entering the metal, therefore, produces a deep zone most highly carburized at the edge, and with the carbon content continually and uniformly decreasing toward the interior. A second wave of three hundred molecules of carbon monoxide entering the metal from the pure carbon monoxide atmosphere finds in the exterior layer a mixture of monoxide and dioxide in equilibrium with .08Austenite. We have assumed this concentration to be CO:CO_2 = 98:1; the additional carbon monoxide arriving enriches the mixture to the proportions CO:CO_2 = 398:1. This condition is now unstable in contact with the low carbon iron with which it is in contact, and the reaction then proceeds (.08Austenite + 398CO + 1CO_2 → .10Austenite + 394CO + 3CO_2) to equilibrium.

The second wave of gas entering the deeper and deeper zones of metal successively augments the action of the previous gas current to the point where action is again stopped by reaching equilibria for .06Austenite: CO:CO_2.

Should the successive waves be pure carbon monoxide gas and continue indefinitely, it would seem that there would be no limit to the carbon concentration attained at the edge of the steel, short of pure iron carbide. In the above, however, we have confined our attention to the inward diffusion of the CO-rich gas, which, while it carburizes, simultaneously enriches the carbon-dioxide concentration at the inner portions of the steel. This carbon dioxide will consequently diffuse outward, to regions of lower concentration, finally reaching that region of lowest concentration existing in the carburizing gas. The continual escape of this carbon dioxide from the steel establishes a certain ratio CO:CO_2 at the surface of the metal, which is really the supply of the successive waves of gas entering the metal.

The highest carbon concentration attainable by the use of carbon monoxide may be called XAustenite, and it is that austenite which is stable with exactly the same CO:CO_2 concentration which exists in the cementing gas enveloping the articles. The limiting carbon concentration attained in a cementation by carbon monoxide is, therefore, dependent upon the equilibrium constant, and not upon the maximum solubility of cementite in gamma iron.

The equilibrium represented by XAustenite is approached in the outer layer of steel with extreme slowness, owing to the counter effect of carbon dioxide diffusing from the lower carbon austenite within toward the gaseous atmosphere. For as the action of carbon monoxide going inward is a carburization, for like reasons a stream of carbon dioxide coming out will decarburize. Indeed, Benedicks[3] shows that this equilibrium may be had in the end only by the additional precaution of keeping the temperature *rigorously* constant during the whole process.

The actual value of XAustenite varies with the equilibrium conditions; that is to say, anything which will shift the reaction (2CO + 3Fe ⇌ Fe_3C + CO_2) to the right will increase the carbon concentration in the muff, and vice versa. Higher carbon cases may be expected

[3] Metallurgie No. 12—14 (1906).

FIG. 7—MICROSECTION OF EDGE OF BAR CARBURIZED WITH ETHYLENE, 5 HR. AT 1050 DEG. C.

from a decrease in temperature, an increase in pressure, or a larger supply of carbon monoxide— a higher gas velocity. The first two statements follow directly from the principle of Le Chatelier, inasmuch as the reaction is exothermic and attendant with decrease in volume. From a practical standpoint, however, the theoretical increase in carbon concentration attainable at lower temperatures is more than nullified by the consequent lowering of speed with which the system approaches equilibrium. A higher gas velocity will undoubtedly give a higher concentration simply because the carbon dioxide produced by the reaction given above is swept away as rapidly as it is liberated. This largely increases the ratio CO:CO_2 existing at the surface of the metal, with attendant increase in carbon content of X-Austenite.

Mechanism of Action of Hydrocarbons

Cemented zones belonging to Giolitti's Type II are produced by the use of ethylene, methane, acetylene, or other hydrocarbons which decompose at elevated temperatures when in contact with iron, depositing a larger or smaller quantity of finest carbon on the outside of the specimen. The distinctive feature of cementations of Type II is the possession of a hypereutectoid case, whereas Type I always produces hypoeutectoid zones. In addition to this characteristic, a slowly cooled zone of Type II shows the existence of three distinct zones shown plainly in the micrograph, Fig. 7 (reproduced from Giolitti, Fig. 38), and the corresponding concentration-depth diagram, Fig. 8 (reproduced from Giolitti, Fig. 37), which are produced by a four-hour cementation in ethylene at 1050 deg. C.

Dr. Giolitti does not fully develop the theory of the mechanism of carburization of zones of his Type II. The action of carbon monoxide may not appear to be simple, but the equilibria C:CO:CO_2 have been quite well worked out in comparison with those of the systems Hydrocarbon:H:C. In general, the specific carburization by means of hydrocarbons may be said to rest upon the relation C_aH_b ⇌ C_dH_e + C_fH_g + C_hH_i +

.... + ... + yH_2 + xC. At the high temperatures of industrial cementation (1000 to 1100 deg. C.) the decomposition products represent a very complex series of compounds.

As before noted, the decomposition upon entering the steel is so rapid that a deposit of carbon is formed on the outside of the steel much more rapidly than it can diffuse into the metal. This lavish deposition of carbon evidently continues as the gases penetrate farther, the direct action of the decomposing gases being intensified by the presence of the excess of carbon deposited on the surface of the sample as well as being possibly reinforced by the diffusion of the carbon bodily into the steel (perhaps a considerable factor in this instance owing to the fine subdivision and the intimate contact of the sooty deposit). For these reasons a high carbon concentration is obtained with a zone of XAustenite of considerable thickness (1 mm.+).

The depth of the entire carbonization and the carbon content of XAustenite will vary widely with variations in the velocity of the decomposition reactions and the conditions of equilibrium, being increased by an increase in the quantity of gas supplied per unit time, the temperature and pressure, and further affected by such variables as the composition of the original hydrocarbon gas and of the steel. Owing to such conditions, the process is hard to control, and such gases cannot be used undiluted for work where some particular depth or percentage carbon is required.

Liquation of Cementite and Ferrite

Notwithstanding the slight direct applicability to industrial uses, cements of Type II produce such extraordinary carbon distributions as to demand further discussion. Should such a specimen as that analyzed and plotted in Fig. 8 be quenched immediately after the cementation is finished, the outer case of XAustenite containing 1.35 per cent carbon would be underlain by a zone where the carbon content falls off rapidly and *continuously* to the unaffected core. Such quenching suppresses the pearlitic band so prominent in Fig. 7.

However, when a temperature is reached where the carbon content of XAustenite exactly equals the maximum solubility of cementite in gamma iron, the necessary time will be provided during a *slower* cooling for primary cementite crystals to be deposited from the now saturated mother solution at the outer edge of the metal. With further lowering of the temperature, the solubility of cementite in Austenite is further reduced, and the lower carbon zones immediately underlying the saturated edge start precipitating their cementite. This collects about the first deposited cementite crystals, which act as nuclei, thus t e n d i n g to enrich the outer layer in carbon.

Conditions at the center of the specimen are exactly similar with reference to the primary ferrite crystals depositing from the low-carbon austenite at that region. As the temperature approaches 690 deg. C., therefore, the ferrite crystals in the l o w - c a r b o n zones migrate inward slightly, collecting upon the

FIG. 9—MICROSECTION OF EDGE OF BAR CARBURIZED AT ABOUT 800 DEG. C.

nuclei furnished by the crystals precipitated previously.

The result of a slow cooling is the production of three distinct zones; namely, a high carbon case, a low carbon core, and between these two a band of pearlite in the neighborhood of 1 mm. thick. This latter zone is the result of liquation—the region is impoverished by the migration of cementite outwards and ferrite inwards.

Cementation in Beta Iron

Another manner of variation in the carbon content results from low-temperature cementations in gases of Type II. Let the temperature be such that the ferrite crystals of the original normal steel are in the beta modification—say, 800 deg. C. In this case the carbon precipitated on and within the iron is absorbed only at those isolated portions previously occupied by the pearlite segregations, the iron of which is now in the gamma form. The carbon content of the exterior portion of the iron is, therefore, increased by virtue of absorption and diffusion with extreme slowness. This outer edge finally reaches a carbon content representing that which transforms it into gamma iron at the temperature in question—0.4 per cent carbon in this instance—w h e r e - after cementation will go forward rapidly. The inner limit of the gamma iron zone is being continually pushed toward the center of the specimen at a low rate, and the resulting case has as before three distinct zones, as follows: a muff of high carbon, practically XAustenite; a low carbon core; and a narrow band where the carbon content increases very rapidly. The characteristics of this class of carburized

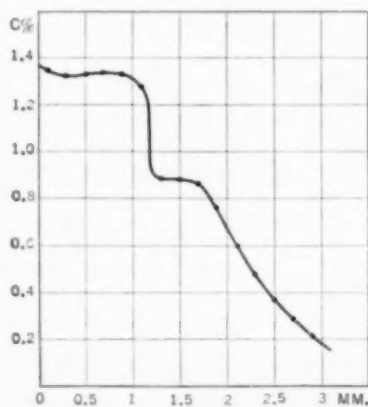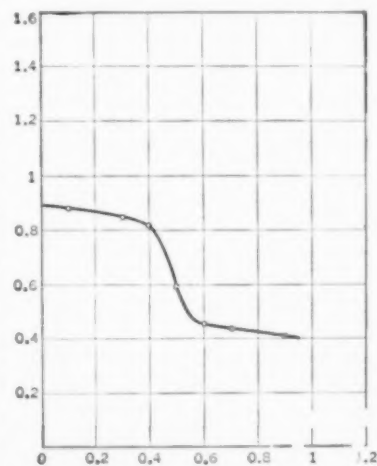FIG. 8 — CONCENTRATION-DEPTH DIAGRAM OF BAR CARBURIZED WITH ETHYLENE, 5 HR. AT 1050 DEG. C.

FIG. 10 — CONCENTRATION-DEPTH DIAGRAM OF BAR CARBURIZED WITH ETHYLENE, 4 HR. AT 800 DEG. C.
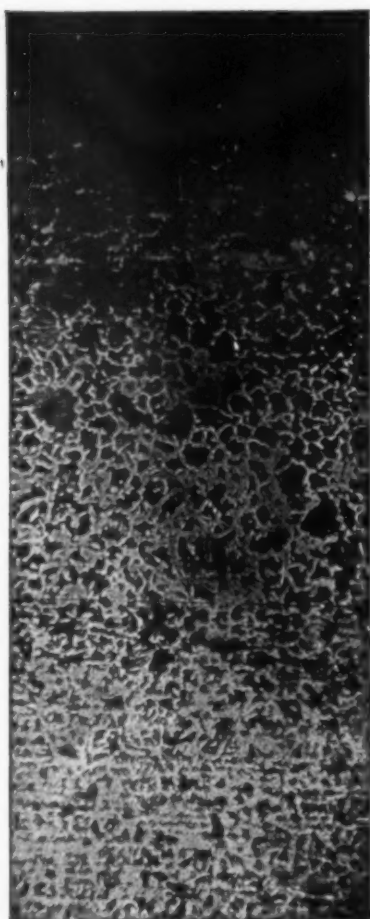
FIG. 11—MICROSECTION OF EDGE OF BAR CARBURIZED WITH GIOLITTI'S MIXED CEMENT (50x), 2 HR. AT 1000 DEG. C.

muffs are illustrated in the micrograph at 60 magnifications, Fig. 9 (reproduced from Giolitti, Fig. 35), and the concentration-depth diagram, Fig. 10 (reproduced from Giolitti, Fig. 43).

Zones of Type III

Cemented zones belonging to Giolitti's Type III are produced by illuminating gas or various mixtures of gases of Types I and II. At high temperatures these give rise to carburized cases of varying thicknesses approximating eutectoid composition at the exterior, underlain by steel of constantly and uniformly decreasing carbon content merging into the unaffected core. The characteristics of this class of carburized zones are illustrated in the micrograph, Fig. 11 (reproduced from Giolitti, Fig. 142), and the concentration-depth diagram, Fig. 12) reproduced from Giolitti, Fig. 45).

Type III is seen to be "intermediate" between Types I and II, and in fact is the result of a plain carbon monoxide cementation (Type I) "intensified" by the action of the pulverulent carbon deposited on the surface and in the exterior layers of the steel by the decomposing hydrocarbons.

Referring to the explanation of the mechanism of the carburization by carbon monoxide, it is seen that the equilibrium of the system ($C:CO:CO_2$) is maintained continuously in the outer layers of the steel by the constant deposition of carbon from the hydrocarbons; this carbon is being continually transferred inwards by the diffusing $CO:CO_2$ gas. Carbon monoxide, in fact, appears to act with maximum intensity in the immediate proximity of free carbon, diminishing with the increasing time necessary to diffuse through the larger distances between the zone of enrichment and the zone of regeneration. In other words, the result of an industrial cementation, which represents some stage before complete equilibrium, depends upon the *speed* of the diffusion and reactions involved.

In Type III the undesirable discontinuous variations in carbon concentration of Type II are eliminated because the hypereutectoid outer zone is non-existent. They may, therefore, be cooled slowly from the austenitic condition without a segregation of the cementite.

FIG. 12—CONCENTRATION-DEPTH DIAGRAM OF BAR CARBURIZED WITH CARBON MONOXIDE PLUS 3.1 PER CENT ETHYLENE, 4 HR. AT 1000 DEG. C.

There will, however, be a slight segregation of ferrite on slow cooling, but this is of much smaller importance in these deep zones than in the shallow ones of Type II, because the discontinuity thus formed is of limited extent and therefore represents a considerably smaller proportion of the whole. Even such segregation about nucleii of ferrite crystals may be obviated by quenching from the carburizing temperature. It is also of importance that this temperature be well above Ac,, else concentration depth curves similar to those of Fig. 10 are formed, and for precisely the same reasons.

Practice of Cementation by Gases

The many advantages accruing from the use of gaseous cements have only been recently realized. Formerly such methods were confined to the production of very deep cementations (20 mm. +) on armor plate. The Machlet furnace, Fig. 13 (reproduced from Giolitti, Fig. 126), has now made possible the use of gaseous cements in small establishments. This is a gas-fired, horizontal, cylindrical furnace, containing a slowly rotating cylindrical steel crucible (2) concentric with the furnace and surrounded by the flames. The crucible has gas openings at the center of each end (33 and 49) in order that a steady stream of carburizing gas may be passed through the hot crucible in which are rumbled the small articles for carburization. At the completion of the run, the contents of the furnace are discharged rapidly by removing the crucible end (32) and raking them out, when they fall directly into the quenching medium (84).

The gas used in such furnaces would be preferably pure carbon monoxide were it not as already pointed

FIG. 13—LONGITUDINAL SECTION OF MACHLET FURNACE

out, that this gas alone or as produced in the ordinary mixed gas producer acts very slowly, that is, it is too "mild." It is usual to enrich such producer gas by pumping a regulated quantity of it through a steam-heated bath of petroleum. The vaporization of the hydrocarbons, when properly controlled, will enrich the producer gas to a point where the gaseous mixture becomes a "sudden" cement, and will precipitate carbon on the surface of the pieces. Under these conditions a case of the "intermediate" Type III described above is produced.
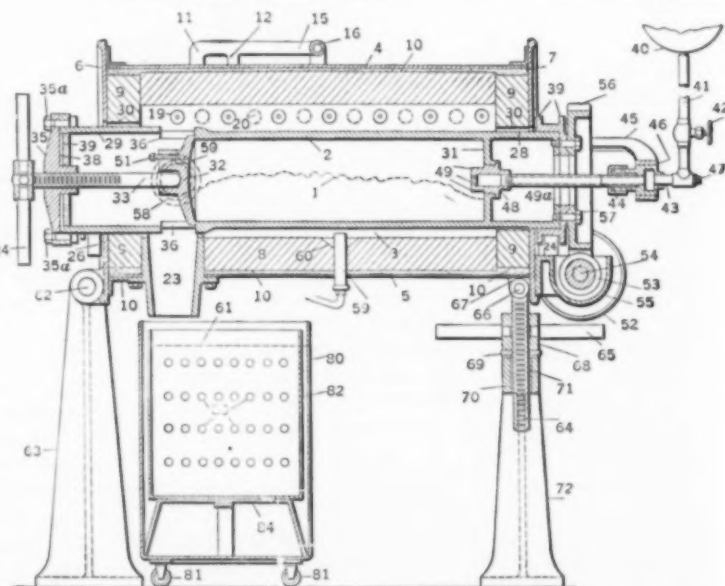
By the regulation of the various percentages of vaporized fuel oil and producer gas entering the retort, the concentration-depth characteristics of the carbonization may be closely controlled. In normal work, a penetration of from 0.7 to 1.2 mm. may be obtained in an hour with a maximum carbon concentration approaching 0.9 per cent. Such a case, by the way, is ample for 99 per cent of all machine parts subjected to partial carbonization.

On the whole, the Machlet furnace is very good for small intricate pieces, but less so for larger, more bulky or flat articles which, in addition, are perhaps not to be cemented over the whole surface. For larger pieces more elaborate furnaces are installed, very similar to those used for "mixed" cements which will be described later.

Mixed Cements

It has been seen that a gaseous cement consisting of a small percentage of hydrocarbons mixed with carbon monoxide raises the concentration of the carbon in the cemented zone above that to be expected from the latter gas alone. Successive additions of hydrocarbons proportionately increase the carbon content up to a point where a carbon deposit is formed on the steel—that is to say, where gas decomposes faster than it passes through the carbon monoxide stage and thence into the steel. Beyond this point the action is like that of a solid cement—the granular charcoal being merely replaced by the finely divided soot which is deposited on the steel.

Thus there is hardly any line of demarcation between the action of some gaseous mixtures and a "mixed" cement consisting of a solid cement acting in conjunction with a gas current—or more particularly as recommended by Dr. Giolitti, a current of carbon dioxide passing through a retort containing granular wood charcoal. In general, at the normal temperatures of cementation (at which steel exists as austenite), atmospheric pressure, and in the short time allowed, Dr. Giolitti's mixed cement produces zones of the intermediate Type III mentioned above, doubtless in all respects the most desirable kind of carbonization yet devised.

The theory of the action of this mixed cement has been sufficiently discussed in the preceding pages; the advantages accruing with its use may be profitably listed. A mixed cement consisting of a current of $CO:CO_2$ over hot carbon (wood charcoal) has a perfectly definite and simple composition, and will add absolutely nothing but carbon to the steel. It is non-exhaustible. The reactions lead to equilibria corresponding to definite carbon concentrations in the austenite, and consequently the results can be easily and closely predicted for wide variations in the carbon content in the original steel without the use of "spies." The diffusion of $CO:CO_2$ into the steel is rapid, which results in a high velocity of penetration of the carbon, and great uniformity and continuity in its distribution. The sur-

faces are perfectly unaltered; and carburization is uniform over the most intricate shapes. Speed of carburizing is attained by charging hot metal and hot granular carbon into a hot muffle, which in addition reduces the danger of distortion to a minimum.

Practice of Cementation with Mixed Cements

The furnaces used for "mixed" cements are of the muffle type—horizontal muffles for small pieces, and vertical muffles or retorts for larger. In the former case a cast iron retort shown in cross section in Fig. 14 (reproduced from Giolitti, Figs. 132 and 133), is mounted in a suitable gas-fired oven. At the front is bolted an extension containing flanged outlets, top and bottom, for the entrance and exit of the granular cement. The doors are hinged in such a way as to allow partial filling of the muffle. Four perforated pipes for the gas supply enter through the front end and lie along the floor of the retort. Upon these pipes are placed ten centimeters of granular carbon, filling the retort up to the first projection on the side walls, upon which is then slid a rack containing the pieces to be carburized, and the remaining space filled with carbon, pushed to the rear by a special hoe resting on the upper projections and operating through the top half of the hinged door. The filling operations are much accelerated owing to the fact that hot granulated carbon will "run" out quite flat, acting somewhat like a mobile liquid.

The gas furnished these retorts is dry carbon dioxide from the ordinary high-pressure drums, up to 1 cu. ft. per hour of the gas being required per square foot of the surface to be carburized. Passing through the 10 cm. of hot carbon intervening between the pipes and the rack of steel articles is quite sufficient for the equilibrium of the system $C:CO:CO_2$ to be established. On completion of the process (two hours are required for cases up to 1 mm. thick) the drain in the bottom is opened, the hot carbon readily runs out into a tank placed below for its reception, the rack containing the cemented articles withdrawn, quenched, and replaced by another from a preheating oven, and the tank full of hot carbon then discharged back into the retort through the opening in the top. These operations are effected in not more than fifteen minutes, a carburizing temperature of 1000 deg. C. is regained after twenty minutes more—in this way nine complete operations may be effected in twenty-four hours.

For the cementation of larger quantities of pieces, or of large flat pieces such as gear wheels, more elaborate furnaces similar to Fig. 15 are constructed (reproduced from Giolitti, Fig. 130). (In passing it should be
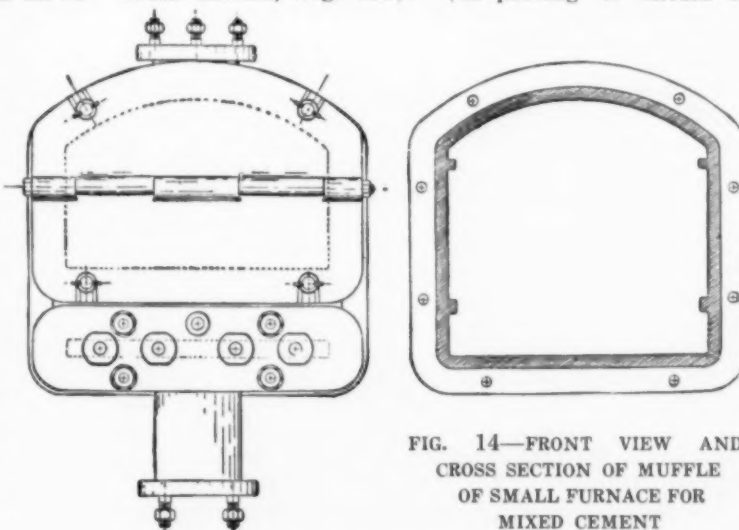

FIG. 14—FRONT VIEW AND CROSS SECTION OF MUFFLE OF SMALL FURNACE FOR MIXED CEMENT

stated that furnaces of exactly the same type are in use for cementation with gaseous cements.) These furnaces have fixed vertical retorts of steel (*A*) set in a refractory tube for protection against flame erosion. Heating is effected by producer gas acting in connection with regenerative checkerwork.

The bottom of the retort is closed by a close fitting hopper *E* and perforated plate *F*, upon which the pieces to be cemented are stacked. In order to facilitate charging and discharging, the entire bottom of the retort may be raised or lowered as desired by the hydraulic plunger *L*, when a column of preheated cylindrical pieces may be stacked up, or loaded in by basketfuls. Hot granular carbon is then run into the retort, which owing to its mobility at the elevated temperature, entirely and effectually submerges all the pieces, entering into all irregularities of the surface with great ease and surety. The cover is then closed, and a stream of carbon dioxide enters by a pipe connection attached to the base *D*.

As in the case of the smaller horizontal retorts, the carburizing temperature is reached in ten minutes, a temperature control of 10 deg. is maintained, and a case 1 mm. thick can be obtained in two hours. Discharging is preceded by drawing off the carbon through a spout at the bottom of the retort *B* into a tank *O*, and removing the cover. The hydraulic plunger then lifts the carburized contents up to the level of the working platform where they are removed and quenched. In this manner from ten to twenty cementations can be effected in a day of twenty-four hours (depending upon the depth of a case required), turning out from one to five tons of material at a maximum cost of one cent per pound—one-fifth that of carburization in boxes.

In installations of this kind perfect uniformity of cementing action is maintained easily by attention to the following details: charge the pieces from a preheating furnace at a uniform temperature; provide a uniform, slow circulation of the carbon monoxide; have clean, dust-free charcoal of about rice size; maintain a uniform carburization temperature by careful design and operation of the furnace.

Exceptionally good results are had in deep zones by a long cementation with carbon—which produces a hypereutectoid zone—then, without interrupting the flow of gas, withdraw the carbon from about the steel pieces and work with carbon monoxide alone for some time. The gas at the end of the operation acts as an "equalizer," transferring the carbon from the high concentration at the edge into deeper and deeper zones. The hypereutectoid zone disappears first, and if the process is continued long enough, the eutectoid zone also is impoverished, approaching the equilibrium of the familiar system XAustenite:CO:CO$_2$, but from the opposite direction.

Deeper zones may also be had in a more direct man-
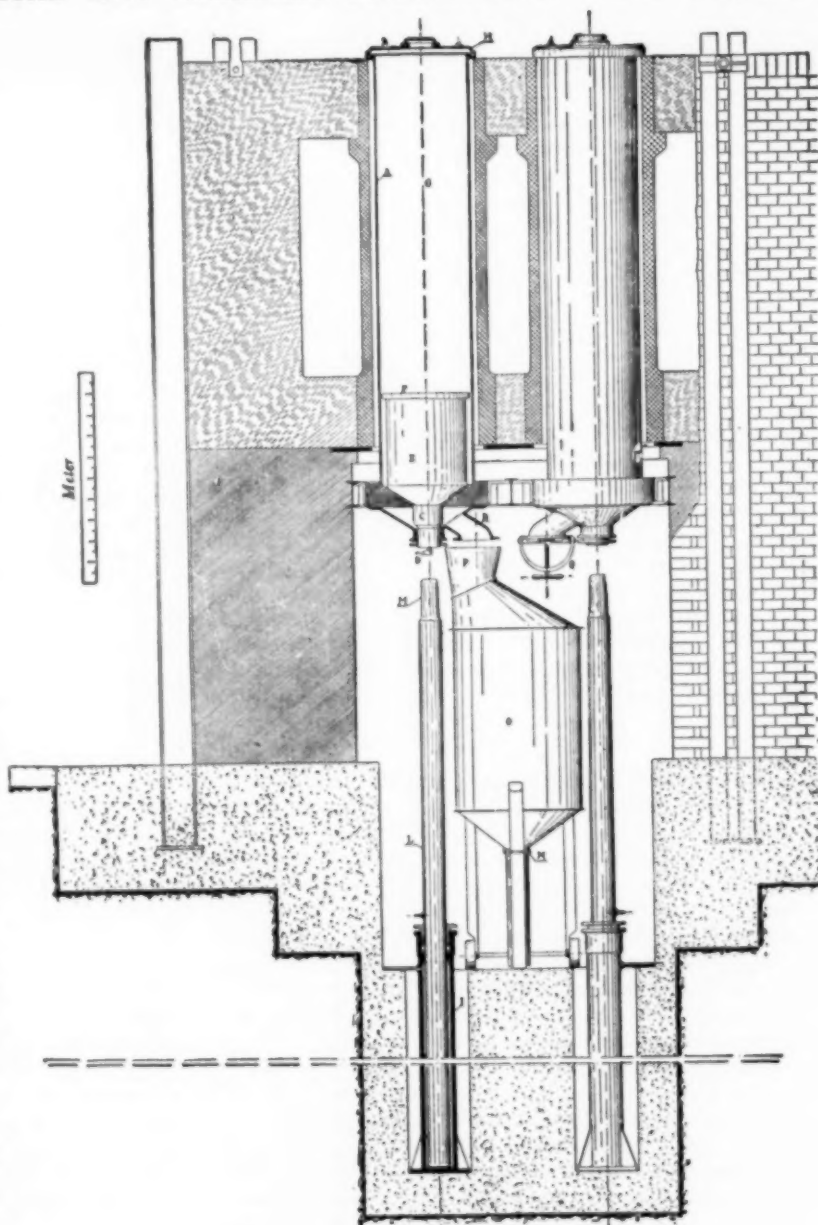
FIG. 15—SECTIONAL ELEVATION OF LARGE VERTICAL ANSALDO FURNACE FOR MIXED CEMENT

ner by diminishing the partial pressure of the carbon monoxide in the mixture by the introduction of an inert gas—this may easily be done by replacing the stream of carbon dioxide entering the retort with air. The resulting gas has a large amount of "inert" nitrogen; as an instance of the operation of such a cement, it may be said that a twelve-hour cementation at 1100 deg. C. gives a *very* deep zone of *very* uniform hypoeutectoid steel.

Additional Problems in Carbonization

Certain features of the text have not been dwelt upon here. Dr. Giolitti presents data regarding the cementation of special steels—admittedly fragmentary owing to the fact that such processes are confined in large part to secret methods for the manufacture of ordnance and armor.

Again, Dr. Giolitti mentions the fact that large accumulations of free cementite crystals result from oscillations in temperature during cementation. This experimental fact is unquestioned, but the theoretical explanation advanced by him is not altogether convincing.

Work in the metallurgical laboratory of the University of Cincinnati is now in progress by which it is hoped to shed more light upon this matter.

A perplexing and most troublesome phenomenon attendant with the use of cemented steel objects is the exfoliation or splitting, of the carburized zone from the body of the piece during quenching or in use. Dr. Giolitti shows that these failures occur at points where a sudden and discontinuous variation in carbon content occurs in the carburized zone—as in the case of the middle zone in cementations of Type II. He explains the facts by referring in a more or less vague way to the abrupt differences of "mechanical properties" which exist in the neighborhood of these layers. This matter has been much clarified recently by Mr. E. P. Stenger, instructor in Metallurgy at the University of Cincinnati, in an important research, which will be published in a succeeding issue in this journal.

Cincinnati, Ohio.

Chemical Porcelain; Its Production and Quality*

By Professor Chas. F. Binns

The present tumult in Europe has focussed attention upon many articles of commerce for which America has depended upon importations, and among these articles chemical porcelain occupies an important place. Germany has had almost a monopoly of the production of this ware and the porcelains of Berlin and Meissen are accepted as of standard quality. Denmark has recently entered the field with an excellent porcelain and Japan is offering a supply of wares which, if not equal to the best, are capable of use. One or two attempts have been made in the United States to meet the demand, but so far the desired quality has not been reached.

In opening a discussion upon this subject the endeavor should be made to establish a clear conception of the material to be considered, what it is, how it comes into being, how its quality is acquired and upon what this depends. In short, to take as complete a view of the field as may be found possible within the allotted time.

The substance known as porcelain owes its name to a supposed similarity to a shell, cyprea porcellana, which was used in the sixteenth century as an object of art. This shell bears a similarity in shape to a hog's back, and this it was which called forth the name "porcellana." The name was finally passed on to the shell-like substance of which the origin was then shrouded in obscurity. Perhaps in allusion to this nomenclature an early Italian writer stated that porcelain was composed of eggs, shells of marine locusts and like ingredients. It was further credited with the property of bursting in pieces if used as a receptacle for poison. This supposed property doubtless enhanced the value of porcelain vessels at that time.

The original ware was made by the Chinese, who reached the perfection of their art in the fourteenth century. The first hard porcelain of Europe was made at Meissen in Saxony in 1710, though this had been preceded in France by the manufacture of soft porcelain.

The manufacture of porcelain, while doubtless perfected by accident, exhibits a development which must be interesting to chemists. In all the ceramic production of the East the firing was originally performed under reducing conditions. The black glaze of the Greeks was largely composed of ferrous oxide, the gray ware of the Romans was colored by carbon and ferrous

oxide together, the alkaline glaze of the Mohammedan peoples was made possible by a reducing fire which dissipated the fumes of sulphur, and in like manner the Chinese resorted to the reducing fire in order to change the natural yellow tone of their clays, which was caused by the presence of ferric oxide, to a grayish blue tone which resulted from a conversion of this oxide to the ferrous form.

But now a further condition arose. In order to produce a brilliant glaze, materials must be found which would not be influenced by reduction. This eliminated the compounds of lead, tin and zinc. The consequence was that the only glaze which met the conditions was one which demanded an extremely high temperature for perfect maturity and brilliance. Such a glaze was at first made by grinding a pegmatic and mixing it with wood ashes. The result is now attained by mixing feldspar, marble dust, clay and quartz. Thus it is not too much to say that the philosophy of porcelain production is founded upon the reducing fire and the hard glaze. The underlying body was selected or prepared to meet the conditions imposed by the glaze and this in turn was compelled to meet the demands of the reducing fire. The body and glaze contain the same oxides, silica, alumina, lime and potash. Nothing else is essential. Almost everything else is detrimental.

In the early practice the glaze, ground in water to a creamy liquid, was laid on the raw clay with a brush. In modern times the clay is ignited to about 1000 deg. C. so as to facilitate handling. It is then dipped into the fluid glaze and the finishing fire, approximately 1430 deg. C., matures body and glaze together. A low temperature is necessary for the first burning because if the ferric oxide in the clay should be inclosed in a vitreous or non-permeable mass the subsequent reducing fire would have no effect upon it and the yellow tone would not be changed to the necessary blue.

The Chinese potters found a pure white clay at the top of a certain mountain which was called "Kao Ling," meaning Lofty Hill. The early French missionaries took this name to be that of the clay itself and so the name became anglicized into "kaolin" and has passed into mineralogy in the form of "kaolinite." Kaolinite is a rare form of a hydrous aluminum silicate which crystallizes in horizontal plates. The substance known as kaolin is a residual clay which results from the decomposition of feldspars. Kaolinite crystals are sometimes present, but for the most part the clay is massive and contains undecomposed feldspar grains and some quartz. It is washed at the mine and while it varies to some extent in purity the clays which are offered on the market approach closely to the composition of kaolinite. The usual impurities consist of ferric oxide and small quantities of lime, feldspar, and quartz. The iron, even to the amount of one per cent, need not be objectionable because, as already explained, the reducing action of the kiln causes it to develop the bluish shade which is characteristic of porcelain. Kaolins are usually rather coarse in grain and possess only a low plasticity. For this reason a more plastic clay is sometimes added to the mixture.

Kaolin alone is extremely refractory and therefore some ingredient must be used which will, upon heating, impart the impervious quality necessary to a perfect porcelain. Feldspar, usually and almost invariably a potash feldspar, orthoclase or microcline, is used. A curious fact may be noticed in passing; soda feldspar, while producing vitrification and translucency, will not make a sonorous porcelain. The ware containing soda as a flux sounds dead when struck, while the potash porcelain gives out a clear musical note. No explanation has been offered to account for this phenomenon.

In addition to the clay and feldspar a small amount

of quartz is added to the mixture and two or three per cent of calcium carbonate. The last-named ingredient is not invariably present, but it helps the purity of the color, contributes to the vitrification and increases the strength of the ware.

The ingredients are usually tested with great care. In the best practice the analysis of the materials is carefully checked. The clay is apt to vary in the respective amounts of feldspar and quartz grains contained and the feldspar will vary as to the percentage of potash. This is important because it is solely for its potash content that the feldspar is used. Feldspar always contains quartz inclusions so that unless the mineral is carefully selected before grinding the content of quartz will vary considerably. This, of course, affects the percentage of potash. Furthermore, feldspars are undergoing a continual decomposition. Some of the potash is being leached out, leaving a residue of clay. Thus it is not uncommon to find a commercial feldspar containing only 13 or 14 per cent of potash, while the theoretical percentage is 16.9.

A good grade of quartz is usually 98-99 per cent silica and is taken to be pure. The clay is received at the manufactory supposedly ready for use. It has been washed and floated at the mine and is shipped dry. The feldspar and quartz are ground by the miller and are received in the form of dry powder. The proper mixture having been determined, a point which will be discussed later, the ingredients are weighed out in batches of convenient size.

At this point it may be worth while to explain the different methods of clay mixing because an understanding of these will materially help in forming an opinion upon results.

The American plan is to feed the whole charge of weighed material into a tank known as a blunger. This is fitted with one or two vertical shafts which are furnished with steel blades. An abundance of water is used and a brisk motion is maintained until the whole charge of clay and other materials is reduced to a thin fluid. This is then strained through screens of brass wire cloth or silk lawn having 100 or 120 meshes to the linear inch. The material can be used in the liquid form or the water can be expressed and the clay passed on to the workmen.

The process which prevails in England is to grind each non-plastic substance separately in water and to blunge the clays each by itself. The mixing is then performed by measure, the specific gravity of each fluid being adjusted. Thus no material is used which is not fine enough to remain suspended in water.

The plan adopted in France and Germany is different. Like the English potters the Continental workers recognize the importance of grinding, but they usually weigh the batch and grind it, while the English mix the batch from an already ground fluid stock. In Germany either the whole batch is ground in a cylinder or the quartz and feldspar are ground and mixed with the clay which has meanwhile been blunged and screened. The potters of the Old World have long recognized that fine wares cannot be made except from very finely ground materials. The American potter finds this too tedious and expensive. He goes to a trade miller and buys pulverized quartz and feldspar presumably ready for use. It is only necessary to stir the mix with water and the clay is ready. Lest it be thought that this is an unfair comparison it should be added that the American potter is not attempting to make porcelain. He makes a strong earthenware which he names semi-porcelain, and when he essays to make a translucent china he has to grind his materials fine, as is done in Europe.

As a part of the process it is the usual practice everywhere to pass the fluid clay—known as slip—through magnetic fields to extract the iron dust which has found its way into the materials. If left in the clay this iron would produce minute black specks.

The clay body is shaped into the required wares by one of several processes. The clay is formed on the potter's wheel by hand, a process which is not now in commercial use to any great extent. Or the clay is shaped in a mold made of plaster of paris; this is the common method for table wares and large pieces. Or the clay is dried to a moist dust and pressed into steel molds; this is in extensive use for the production of wall tile and electrical insulators. Or the fluid clay is shaped in plaster molds by the process of casting; as this process is used for the production of chemical porcelain, it will be well to describe it more fully. First as to the preparation of the slip. It has already been shown that the first stage of the mixing results in slip from which clay is afterward prepared by expressing a part of the water.

Slip of this character can be thickened by subsidence, decantation and evaporation until it becomes thick enough for use in casting, but even then, to be fluid enough to pour, it must contain 50 to 60 per cent water. It has been found, however, that by the addition of *electrolyte*, which deflocculates the clay, a fluid slip can be produced with a water content of only 30 to 40 per cent or about 10 per cent higher than the water content of the clay when in plastic form. This expedient results, of course, in very much less shrinkage in drying and burning, moreover it makes the working of the slip much easier. There are two ways of performing the operation, for it will not suffice merely to add electrolyte to a thick slip. In the original plan the proper charge of material was weighed and fed to a grinding mill. A measured quantity of water was added and about 1 per cent of a mixture of equal parts of sodium silicate and dry sodium carbonate. The whole batch was then ground until fine enough for use. The objection to this method is that as the addition of more water would spoil the slip it was necessary to screen it while in the viscous condition which is demanded for proper use. This involved a great deal of trouble and much material was lost. The better plan is to take some of the slip which has been made in the regular way, pump it through the filter press to extract the water and then to reduce the plastic, stiffened clay to slip again. It has already been screened, so that a second refining is not necessary. The plastic clay is weighed, 10 per cent of water added with the proper amount of electrolyte and the whole charge placed in a mill to be reduced to a smooth viscous slip. This is simply run out when ready and is supplied to the potters for use. The slip, when in proper condition, should weigh 1.60 grams per cc.

The process of casting is simple, but usually arouses interest and inquiry, because it is different from the casting of metals. The casting of pottery depends upon the use of porous molds. Molds made of plaster of paris possess this property when dry. The slip is poured into the mold and suction at once begins. The porous walls absorb the water rapidly and the clay which was held in suspension is built up, particle by particle, in an even coating over the inner wall of the mold. More slip being supplied the process of building continues until the coating of clay reaches the required thickness. When this is the case the mold is emptied of the superfluous slip and set aside to drain. In a few moments the clay vessel will have become dry enough to shrink away from the walls of the mold. It can then be removed, dried thoroughly, finished smooth on the edge and burned. The handle of the casserole and the little ring on the crucible cover are made separately and fastened to the body pieces by using a little thick slip as a cement.

The matter of the composition of the porcelain body may now be discussed. As already stated, the body may contain clay of two kinds, plastic and non-plastic; ground feldspar and ground quartz. The small quantity of calcium carbonate may be ignored. It is simply added in the form of whiting as may be required by the terms of the recipe in use.

The best chemical porcelains contain about 80 per cent clay, 10 per cent feldspar and 10 per cent quartz. These figures mean nothing to a layman, but for the purpose of illustration they may be compared with a standard American china mixture (Fig. 1). This is:

Kaolin	27
Plastic clay	15
Ground feldspar	22
Ground quartz	36

Or a standard earthenware mixture which is:

Kaolin	25
Plastic clay	20
Ground feldspar	15
Ground quartz	40

In addition to these marked differences in composition there are differences introduced by method. The earthenware is mixed from commercial materials without further preparation, the china and the porcelain bodies are both ground to an additional fineness. Further, the earthenware and china bodies are manufactured by the two-fire process, the body being matured first and the glaze fused upon it afterward at a lower temperature. The porcelain is matured at one-fire only, body and glaze undergoing the same burning. And yet, again, the earthenware is exposed to a temperature of pyrometric cone 8 or 1290 deg. C. for the body and cone 6 or 1250 deg. C. for the glaze; the china to cone 10, 1350 deg. C for the body and cone 6, 1250 deg. C. for glaze; the porcelain to cone 16, 1450 deg. C. for both body and glaze.

It will not be necessary to discuss the composition of the more fusible glazes. They owe their low softening point to the presence of lead oxide and boric acid. The porcelain glaze, however, may be considered more fully. A glaze for chemical porcelain, to become smooth and brilliant at or about 1450 deg. should correspond to the empirical formula:
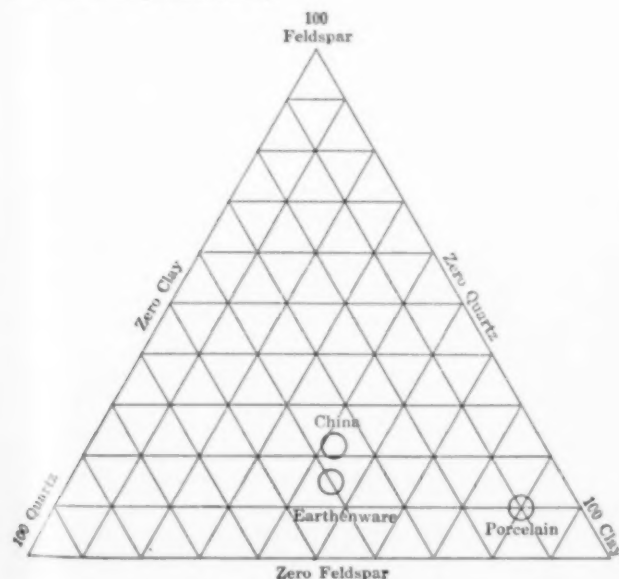
$$\left.\begin{array}{l} 0.3\ K_2O \\ 0.7\ CaO \end{array}\right\}\ 0.9\ Al_2O_3,\ 9.0\ SiO_2.$$

This will be produced by

FIG. 1—TRIAXIAL DIAGRAM

Feldspar	22 parts
Whiting	9
Clay	21
Quartz	48

The materials are weighed dry and ground in water to a creamy liquid. A fine screen arrests all unground particles, and the dehydrated clay ware which is porous and fragile is dipped rapidly and dried.

The technique of porcelain firing is very intricate and important. The earthenware and china made in this country being burned on the two-fire plan, there has been no opportunity to acquire the specialized skill which porcelain demands. The difference is this: When any ware is brought to its full maturity while in the unglazed or biscuit condition the pieces can be packed in fine sand or pulverized quartz. All vitrified wares become flexible when at the maximum temperature and the more so as the vitrification is to be the more perfect. Earthenware may be considered almost self-supporting. China requires very careful adjustment and assistance. In burning porcelain, however, no support other than a mere standing place is possible because the pieces are covered with glaze. Any contact between a glazed surface and a support will cause a permanent connection on cooling and will probably break the ware. An examination of any piece of porcelain will reveal a dry surface where the vessel has stood. Porcelain cups and saucers can be easily distinguished from china cups and saucers by this fact. Crucibles are unglazed at the bottom, evaporating dishes are burned upside down and have a dry rim. Casseroles are also burned in this position and the handle has a dry patch at the end, supposedly left as a convenient point for a mark or number, but in reality as a place for a support which will not stick to the unglazed part.

The French and Germans have brought the art of setting their wares to great perfection. They have accumulated a fund of experience and an enormous equipment of appliances of which American potters have no conception. Added to the fact of the viscous, tender surface there is that of the shrinkage. Clay wares are reduced in size in burning according to the nature of the body and the completeness of the vitrification. Cast pieces will shrink from one-eighth to one-sixth in size. Therefore, when true shape is expected supports of raw clay must be prepared which will contract to the same extent and at the same rate as the piece supported. Thus delicate cups are set on clay rings in an inverted position. Large pieces are set on refractory cones which are made at such an angle that the piece will slide over the surface as it contracts without being subject to too much friction. All these facts tend to show how much there is to be learned in this country if the production of porcelain is to proceed.

It now seems to be in order to inquire in what especial condition or circumstance the quality of chemical porcelain resides. The demands upon wares of this type are: First—Low thermal expansion in order to secure resistance to temperature changes. Second—Insolubility under drastic treatment with acids and alkalies. Third—A glaze difficult of fusion to permit heating without softening. The first condition is imposed upon the body, the last two upon the glaze. A pottery body, however it may be composed, undergoes certain changes when heated. These changes are concerned, first, with the dehydration of the clay and the expulsion of the combined water; second, the softening of the feldspar grains and the beginning of their attack upon the less fusible particles; third, the change of the quartz grains through crystobalite to quartz glass, and, lastly, the formation, under the solvent influence of the feldspar, of new combinations, of which silimanite is the most

important. The due progress of these reactions is governed by several things—the mixture, or proportion of the several ingredients, the temperature of the firing and the time taken to reach that temperature.

The heat work of the kilns is gaged by the pyrometric cones which were first produced by Seger, the German ceramist, about 30 years ago. These are not intended to be calibrated in degrees of temperature, for they are greatly influenced by the duration of the burning process. They are, however, a great boon to the practical burner and, moreover, constitute an alphabet of burning information which is most valuable. One can easily understand the significance of a cone 1 kiln or a cone 10 kiln, whereas the terms of temperature do not express the same thing nor are they so readily grasped.

A china body made in this country* is burned to cone 10. In this case the material does not seem to have been very finely ground and the temperature has not been sufficiently high to accomplish much in the way of new combinations. This china is too glassy to meet the conditions which are imposed upon chemical ware, furthermore the glaze is too fusible. This is a compound containing both lead oxide and boric acid. It is probably fused at less than cone 6 (approximately 1250 deg.).

Haviland porcelain made at Limoges, in France, is a true hard porcelain burned on the one-fire plan and matured at about cone 15. The glaze is hard and the body less glassy than the china, but still it will not bear the exacting tests to which chemical porcelain is subjected.

The Meissen porcelain illustrates the complete development of the structure of chemical porcelain. (A slide was shown at the meeting, magnification 190 diameters, made by Mr. A. A. Klein, petrographer of the Bureau of Standards.) It is a section of body and glaze together and beautifully illustrates the growth of crystals of silimanite from the body surface. Crystals of the same compound can be seen in the body structure together with certain masses which Mr. Klein defines as amorphous silimanite.

In this connection it is interesting to quote from a South Kensington Hand Book on English Porcelain by A. H. Church, professor of chemistry in the Royal Academy of Arts of London and an enthusiastic collector of porcelain. He says, "If we bring the microscope to aid us we shall find that all the hard porcelains have a common and distinctive structure which consists in the presence of a vast number of small, straight ended slender rods, called *belonites*, and of many minute granules called *spherulites*, both rods and granules having been formed out of the original materials, but not pre-existing in them." The book from which this quotation is made was published in 1885, but there does not seem to have been much attention paid to the statement quoted, or to the facts set forth, until recent investigators, Mellor in England being probably the first, again called attention to the network of crystal needles which develop in a porcelain body at high temperatures. It is probable that this condition offers an explanation of the ability of a porcelain body to resist thermal changes. A body which contains enough fusible, glassy material to produce density at a low temperature develops a glassy structure with the consequent brittleness. A body in which the fusible ingredient is so small in amount that high temperatures are not only possible but imperative are enabled by the intensity of the fire to so rearrange themselves in new combinations that the tough, interlacing crystals form a highly resistant bond.

*A section magnified 300 diameters was shown by the author at the meeting. See Transactions Amer. Ceramic Society, vol. 18, p. 411, Fig. 12.

The glaze owes its ability to withstand chemical and thermal action to the same high temperature. A comparison of the composition of a hard porcelain glaze with that of lime-soda glass will serve to emphasize this point. The glaze as already given is, in ceramic expression:

$$\left. \begin{array}{l} K_2O\ 0.3 \\ CaO\ 0.7 \end{array} \right\} \begin{array}{cc} Al_2O_3 & SiO_2 \\ 0.9 & 9.0 \end{array}$$
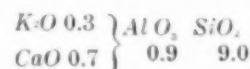
or in percentage:

Silica	78
Alumina	12
Lime	6
Potash	4

The glass corresponds to:

$$\left. \begin{array}{l} Na_2O\ 0.5 \\ CaO\ 0.5 \end{array} \right\} SiO_2\ 2.5$$
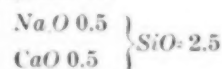
or in percentage:

Silica	71
Lime	14
Soda	15

The high content of the alumina in the glaze is rendered possible by the intense fire while the low alkali content reduces the vulnerable point of the compound to the minimum.

In the laboratories of the State School of Ceramics at Alfred several studies of chemical porcelain have been made and numerous porcelains have been tested. The body of which the location on the triaxial diagram (Fig. 1) has already been given as consisting of 80 per cent clay, 10 per cent quartz and 10 per cent feldspar has been found to be equal to the German porcelains in behavior. The thermal test was made in the following manner which has been adopted as a standard.

The piece to be tested is inclosed in a fire-clay receptacle and exposed to the direct flame of a Meker or other suitable burner until the whole piece glows to a bright red. It is then quickly removed to a support close by and a blast of cold air is directed against one side. When cool the piece is reheated and again cooled. Any sample of porcelain which will withstand ten successive treatments without fracture is adjudged perfect. At the same time note is taken of any adhesion of the porcelain to the triangle upon which it rests. The hardest glaze shows no attachment whatever, and, of course, the softer glazes adhere, sometimes quite strongly. Some domestic porcelains have broken on the first or second heating and in at least one case the fragments clung to each other in a viscous string held together by the softened glaze.

In the case of the special mixture mentioned the pieces were first tested in the unglazed condition having been burned to the maturing point, cone 16, without glazing. Those pieces which stood the ten heatings and coolings perfectly were then glazed and burned a second time to cone 16. The test on the glazed pieces was then carried out and for the second time these porcelains made a perfect score. To ascertain the deformation point of the porcelain body small strips are cut from wares of different make. These strips, one inch high and a quarter of an inch wide at the base, are imbedded in plastic clay so as to stand erect. With the strips are set small cones of known softening point. When the deformation point of a body is reached the strip begins to bend and as the cones bend likewise in regular order an accurate comparison can be made.

The best porcelains begin to soften at cone 25 (1650 deg.) and the laboratory porcelain already discussed stands up a little better than Meissen and Berlin. The American porcelains, so far tested, begin to soften at

cone 15. At the same time the glaze on these wares rolls up into a bubbling wave while a true cone 16 glaze remains smooth.

Other tests were made by evaporating strong acids and alkalies to dryness and it was found that the glaze resisted attack fully as well as the German product. Acids scarcely attack these glazes at all, but no porcelain glaze is entirely resistant to alkaline attack.

It may be stated, therefore, that the production of perfectly satisfactory chemical porcelain is entirely possible if the established conditions be observed.

There remains now to consider the practicability of the American manufacture of chemical porcelains. The fact that such porcelains are being made would seem to prove this point and the reason why the wares have not hitherto proved to be of the best quality is not easy to understand. It has been found true that the American capitalist prefers to trust to the manufacturing experience of some empirical worker rather than to enlist the services of a technically trained man. The fact is that the output of chemical porcelain is not large enough to warrant the erection of a plant for this sole purpose, and it has been thought that the ware could be manufactured as a side line, using the appliances and the kilns already established. The special qualities demanded and the only methods by which these qualities can be secured have not been understood. There is probably not a kiln in this country fired as high as cone 16, which is the requirement, and to make the necessary adjustments in firebrick and refractory accessories presents serious difficulties to those who are accustomed to think in terms of cone 10.

Capital is timid and is accustomed to look out for bad weather ahead. It is feared that on the return of peace in Europe the American market will be again supplied with German porcelains. Inasmuch as a large proportion of these wares is imported duty-free it is not possible to erect a tariff barrier against them and anyone who invests his money in the manufacture is apt to lose it. This attitude more than any other is responsible for the reluctance of manufacturers to make the venture.

Certain wares have been advertised as equal to any in the world, but they have failed to withstand the tests imposed. Other wares prove satisfactory under one test and fail in another. It almost seems as though the persons responsible for the production of these wares were trying to obtain workable results without undergoing the expense of manufacturing the real thing. It must be acknowledged, on the other hand, that in view of the high rate of wages here and of the duty-free importation it will be difficult to compete with Europe.

Perhaps it may be thought that the tests which have been described are too severe. Severe they undoubtedly are. They were devised to exhibit the qualities of the best wares. Berlin, Bavarian, Copenhagen and Meissen stand up under the strain. No domestic porcelain tested so far stands up perfectly, though not all are equally weak.

There is no secret about chemical porcelain. Anyone who is generally skilled in pottery processes and who will take advantage of published information can produce it successfully, but to manufacture it economically and without undue loss there must be an infinite attention to detail and the exercise of unlimited patience.

N. Y. State School of Clay-Working and Ceramics,
Alfred University, Alfred, N. Y.

New German Scholarships in Chemistry.—The Liebig Scholarship Society has recently been formed in Germany for the purpose of aiding German chemical students, after their examinations, to proceed with their studies by working as assistants in the technical high schools. The society at its start had a sum of over 1,000,000 marks donated by the German industries.

Synopsis of Recent Metallurgical and Chemical Literature

An Improved Phosphoroscope.—In the *General Electric Review* for March, 1917, W. S. ANDREWS describes a phosphoroscope which he has developed for determining the fluorescence and phosphorescence of various compounds. The instrument operates by subjecting the object to be tested to the action of ultraviolet rays at short intervals and then exposing the object to the eye during the intermissions, while the exciting rays are cut off, the substance being otherwise in a lightproof chamber. The radiations are produced by means of high-tension disruptive sparks between iron points. By this instrument luminescence can be seen even when its period of afterglow is very short, *i.e.*, what is termed fluorescence as distinguished from phosphorescence where the bodies show luminescence for a considerable period of time after the exciting medium has ceased to act.

Solvent Recovery in Rubber Industry.—In discussing rubber solvents in the *India Rubber World* for March 1, 1917, LOTHAR E. WEBER has the following to say in regard to solvent recovery: "Many attempts have been made to recover or partially recover the gasolene used in certain branches of the rubber industry, notably in the spreading operation. The volume of gasolene in a spreading plant vaporized in the course of a month's operation reaches staggering figures and it is only natural that the recovery of the solvent should have been given serious thought. While theoretically the recovery of gasolene from the spreading operation is a simple matter, the practical difficulties and cost of equipment have so far stood in the way of its applicability. In this connection it is not generally recognized that even if all the gasolene which is vaporized in the spreading room were successfully condensed, the resulting material would have properties differing materially from those of the original gasolene. Owing to the relatively low initial boiling points of gasolene, considerable losses take place during the churning operation; so much so, that if only the gasolene which is vaporized in the spreading room were condensed, its boiling points would be very much higher than those of the original gasolene. The recovery process, in order to make it complete, would have to be extended to the churn room. It can readily be seen, therefore, that the size and cost of equipment of such a complete recovery plant would be high. Nevertheless, there is every reason to expect that a recovery plant would be a good investment if the purely mechanical and engineering difficulties are solved." In commenting on the subject an editorial in the same issue gives the following data: "Most of the solvent mechanisms are either German or English in origin, and were designed for the great proofing establishments abroad. The Weber-Frankenburg, Vincent, Heinzerling and Spendle are the best known. While differing in many details, they do the work in much the same way. In a word, the fabric, as soon as it is proofed, enters a closed chamber, heat volatilizes the solvent, which is carried against cold surfaces, condensing it. Dripping from these surfaces, it is collected in tanks, often in water, drawn off and stored for re-use. The whole apparatus is simple and one that any chemical engineer can construct without difficulty."

Steel Foundry Sand.—That the problem of sand for the steel foundry has for a long time been considered a very important one is evidenced by the tremendous amount of literature available on the subject. The Tropenas Converter Company, in putting steel foundries of its process in operation for customers, was confronted with this chemical sand problem several years ago,

and worked out a solution satisfactory to its engineers. An article on the subject is published in the company's bulletin *Steel Castings* for February, 1917. The authors are G. MUNTZ and E. ROUBIEU. They state that molding sand must be plastic, non-yielding, permeable to gases, capable of resisting high temperatures readily, and after serving its purpose must be easily destroyed. Furthermore, if any material answers all these conditions, its cost will have to be considered, in order to ascertain whether the advantages expected from its use are not to be secured at prohibitive expense. The various particles of silica do not adhere to each other naturally, thus an agglomerating medium will have to be called upon, if the above qualities of silica are to be taken advantage of. Clays have been chosen to agglomerate silica, because they are themselves refractory and can be found most anywhere; some have no plasticity and are, therefore, of no value to cement the silica particles, while others, for some reasons yet unknown, will form with pure silica, a plastic compound which is most suitable as a molding medium. There are other refractory materials possessing a much higher melting point than silica, but on various accounts are not used for molding. Thus, certain clays, such as the Kaolins, fuse at temperatures above those usually encountered in the steel foundry, but molds made of these would have to be dried thoroughly in order to be non-yielding, and in drying would shrink to such an extent and so irregularly that trueness to pattern would be almost impossible to preserve. Besides, permeability to gases would be almost nil, and destruction of the molds, after serving their purpose, would be most difficult. Either magnesia, lime or alumina is more refractory than silica, but not as widely distributed, and all lack some of the qualities indispensable to molding media. It seems then that sand, composed of silica, clay matter and their inherent impurities, is the only material we can use for molding purposes. The authors state that in the steel foundry clay is the necessary evil, as it is the carrier of the fluxes which will attack the almost pure silica of sand. Sands as provided by nature are usually round grained, and, if meeting the chemical requirements, represent the only class that should be used in the steel foundry. The conclusion is reached, quite at variance with usual practice, that sand must be relatively coarser to produce small castings than to turn out large ones. Ideal foundry sand is defined as an agglomeration of spherical particles of silica, each covered with as thin a coating of clay as can be applied on them. Clay is the enemy, it fuses at high temperatures, on account of the impurities it carries, and because of its very fine texture. The coating of clay that each particle of silica is to receive should then be reduced to a minimum. Air floated clay will average from 95 to 98 per cent fineness through a No. 200 sieve, and it is useless to state that if properly handled this material will be ideal for use in connection with such silica sands as are almost devoid of bond. To mix the round-grained, sharp silica sand with air-floated clay, the old pan grinder is yet the most efficient machine, due to the rubbing effect. The best sand, if not properly armored with nails, where the washing action of molten metal is most intense, will frit, causing scales on the one hand, and sand spots wherever the fritted material will be carried to portions where it cannot escape. Extensive areas, such as copes overhanging large bodies of metal, will often cave in if they are not properly armored.

Smoke Abatement.—In the Proceedings of The Engineers Society of Western Pennsylvania, OSBORN MONNETT of the American Radiator Company presents the results of many years of experience in the prevention of smoke. The author was formerly chief smoke inspector of Chicago and in investigating the smoke problem in that city it was found that draft was the most important consideration. From a long series of investigations covering some thousand boiler settings, a curve was developed which gives the draft needed for different rates of combustion. The rule is that 0.01 in. of draft is needed over the fire per pound of coal burned per square foot of grate surface per hour. The limit rate of successful smokeless operation for hand-fired units is about 28 lb. of coal per square foot of grate surface per hour. Above this point reliance is placed on mechanical stokers. The rate of combustion is fixed first in any plant by the load. When this is known, the ratio of grate surface to heating surface is fixed, and these two factors decide the rate of combustion. The curve is then used to determine the draft requirement. In hand-fired furnaces by firing from the top and covering the clean grates with green coal to a depth of 4 or 5 inches, and then building a fire at the bridge wall with kindling or live coals, it is possible to get up steam without violating the smoke ordinance. In cleaning fires, if one side is cleaned out and the grates covered with green coal and then red hot coal thrown on top of the green coal, it is possible to clean a fire without smoking.

Recent Metallurgical and Chemical Patents

Alloys

Alloying of Manganese with Brass and Bronze.—A method of alloying manganese with brass and bronze is patented by Dr. HANS GOLDSCHMIDT and Dr. OTTO WEIL of Essen-on-Ruhr, Germany. The American patent is assigned to the Goldschmidt Thermit Company of New York. Manganese alone is added to brass and bronze baths with difficulty. These difficulties are partly overcome by employing a manganese-copper alloy, but if for making this alloy phosphor-copper is used instead of copper, the components alloy in a shorter time and at a much lower temperature. It is impossible to cast alloys of a high melting point with more than 25 per cent of phosphorus because of the evaporation. The minimum percentage is about 5 per cent phosphorus. The manganese varies between 30 and 50 per cent. The addition of these alloys is stated to greatly improve the quality of the brass and bronze (1,214,539, Feb. 6, 1917).

Brazing Material.—Alloys for brazing electrical connections are the subject of a patent of TRUMAN S. FULLER of Schenectady, N. Y. The patent is assigned to the General Electric Company. For brazing in locomotive armature windings induction motors, etc., it is stated to be necessary that the brazing metal should have a melting point high enough to prevent its melting during brazing and also low enough to allow of melting it for repairing the brazed parts. Other conditions are that the metal should be malleable and tenacious enough to be rolled in a foil and must alloy readily with the metals to be brazed. Alloys suitable for these purposes consist of silver and cadmium, the percentage of silver running from 57 to 65 per cent. Small amounts of other brazing metals, such as copper, are permissible, but readily oxidizable metals such as aluminium must be excluded. The alloy may be prepared by melting silver in a suitable crucible in a hydrogen atmosphere and then adding cadmium in stick form, preferably, somewhat in excess of the desired proportions, as some of the cadmium is volatilized. Instead of pure silver, sterling silver containing about 92.5 per cent silver, and 7.5 per cent copper may be used. Preferably 62.5 per

cent sterling silver and 37.5 per cent cadmium, which results in an alloy of 57.8 per cent silver, 37.5 per cent cadmium and 4.7 per cent copper. This alloy has a melting point of about 750 deg. C. (1,125,138, Feb. 6, 1917).

Alkali Metals and Cyanides

Production of Alkali Metals.—A method of producing metallic sodium or other alkali metal, by electrolysis of molten alkali chloride under a certain amount of pressure is patented by ROBT. J. MCNITT of Niagara Falls, N. Y. The patent is assigned to the Roessler & Hasslacher Chemical Company of New York. A cross-section of the furnace is shown in Fig. 1. The furnace has a graphite anode A, joined to conductors B. The cathode C, is joined to the conductor D at the bottom of the furnace. The total height of the furnace is quite large as compared with the reaction zone between the electrodes. The furnace is filled with sodium chloride to the level shown through the opening Q. The height of this column should be such that a pressure of about 1 lb. per square inch is exerted in the zone of electrolysis. When heated up by the current the sodium chloride becomes molten and metallic sodium is formed at the cathode and chlorine at the anode. A diaphragm K extending from the lower edge of the bell Z to the lower edge of cathode C separates the anode from the cathode compartment. As the sodium is formed it rises in the bell due to the difference in specific gravity between the two liquids. As a column of sufficient height is reached the sodium will flow through pipe N to container O (1,214,808, Feb. 6, 1917).

Manufacture of Cyanides.—A process of making cyanide by the combination of alkali metal vapor, nitrogen and charcoal is patented by HANS FOERSTERLING and HERBERT PHILIPP of Perth Amboy, N. J. The
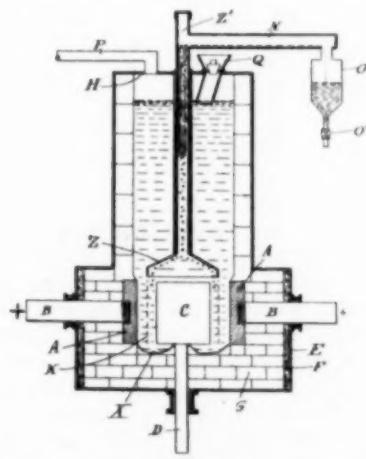

FIG. 1—CROSS SECTION OF ALKALI METAL FURNACE

patent is assigned to the Roessler & Hasslacher Chemical Company of New York. In referring to previous work the patent states that Acker in U. S. patent 914,100 disclosed a process for making cyanogen compounds by electrolyzing a molten compound of a metal with the cathode metal, removing the alloy from the electrolytic cell and reacting on the alloyed metal with nitrogen and carbon. The method described in the present patent differs from Acker's method in that the volatile metal is first separated from the cathode metal and then brought into contact with the nitrogen and carbon. The method of working this process is shown in Fig. 2. The electrolytic chamber is shown at 1, and the electrolyte at 9. The anodes are shown at 7 and the molten cathode at 8. The electrolyte is sodium chloride and

the cathode is molten lead for producing sodium cyanide. A partition 3, having an opening 4 at its right end, connects by means of the seal 5 with the furnace chamber 2, which is heated by a burner 11. In operation the electrolysis furnishes a sodium-lead alloy which passes through the seal 5 into the furnace chamber 2. Here nitrogen is blown through tube 10 and the sodium distils from the alloy and is carried together with the nitrogen over to chamber 15, filled with charcoal, where
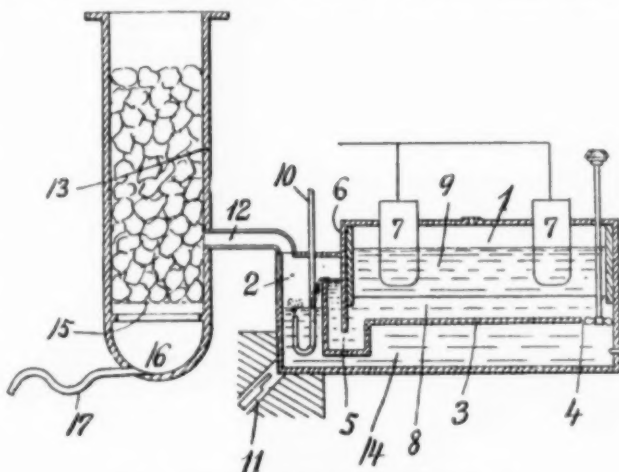
FIG. 2—DIAGRAM OF CYANIDE PROCESS

the cyanide forming reaction takes place. The impoverished alloy flows back through 14 and up through 4. Thus the lead forms a complete cycle and is not used up (1,214,770, Feb. 6, 1917).

Oxygen and Hydrogen

Electrolytic Oxygen and Hydrogen Generator.—An electrolytic hydrogen and oxygen generator with cobalt as the active anode element and iron as the cathode is patented by ISAAC H. LEVIN of New York, N. Y. The generator unit consists of a rectangular thin iron plate casing of small height, long and narrow. Any number of these may be joined together to form a complete generator. The iron casing is divided into two parts by an asbestos diaphragm, suspended from an impermeable partition which reaches about one-fourth of the way down into the cell from the top. An electrode is placed in each compartment formed by the diaphragm. The partition in the upper part of the cell prevents the combination of oxygen and hydrogen after the same have been generated and have risen separately to the top of the cell, being prevented from mixing by the diaphragm. Suitable means are provided for carrying away the gases, filling the generators with electrolyte, etc. The anode is made of iron, electroplated with a thin film of cobalt, and the cathode is of iron, preferably electrolytic. The electrodes are given a previous treatment by making them the anode in a solution of a salt of the active surface metal, and electrolyzing for a brief period. This is claimed to give greater efficiency in operation (1,214,934, Feb. 6, 1917).

Iron and Steel

Refining and Deoxidizing Iron and Steel Scrap.—EDWARD H. SCHWARTZ of Chicago, Ill., patents a process of producing high-grade material from scrap by melting with carbon-steel scrap a proper proportion of silico-spiegel or manganese steel scrap, with or without the addition of pig iron of suitable silicon content. Preliminary smelting may be carried out in a cupola on a bed of coke or coal and then the molten product transferred to an electric, open-hearth or reverberatory fur-

nace or a converter. In treating carbon steel for final electric-furnace treatment about 95 per cent steel scrap and 5 per cent spiegeleisen are used in the cupola charge. In making manganese steel a mixture of 30 per cent manganese-steel scrap, 50 per cent carbon-steel scrap and 20 per cent high-silicon pig iron is used when converter treatment is to follow cupola melting. The process may also be used for the manufacture of semi-steel, gray iron and white iron, using in each case quite large percentages of scrap. The high grade of product obtained is stated to be due to the deoxidizing and refining action of the manganese. The spiegel scrap also exerts a desulfurizing action on the carbon steel scrap when melting in the cupola, and by using limestone as flux more or less phosphorus is eliminated (1,215,065. Feb. 6, 1917).

Miscellaneous Apparatus

Automatic Extraction Apparatus.—An apparatus for the automatic extraction of values from solid substances is patented by RICHARD L. OGDEN of Rahway, N. J. The material to be treated is suitably sized and placed on a colander just beneath the cover of a tank. By an arrangement of pressure tanks and regulators the extracting solution from another tank is sprinkled over the material and is automatically returned to the tank and resprinkled over the material again until the extraction is completed. The necessary air pressure and suction are provided by the raising and lowering of water in a vessel (1,215,182, Feb. 6, 1917).

Explosions Due to Presence of Hydrogen in Electrolytic Oxygen

The attention of the Bureau of Mines, Department of the Interior, has recently been directed to a series of explosions of oxygen made by the electrolytic process in which life has been lost, as a result of hydrogen being mixed with oxygen. The first of these explosions occurred in Cincinnati, the coroner's jury calling attention to the fact that there were no specifications for the purity of oxygen and recommended to Col. B. W. Dunn of the Bureau of Explosives, which bureau publishes regulations regarding the transportation of explosive substances throughout the country, suggesting that that bureau make investigations.

As the Bureau of Explosives did not have any facilities for making such tests Colonel Dunn referred the inquiry to the Bureau of Mines with the request that it investigate the question. The problem is important in view of the extensive use of oxygen for welding and cutting purposes.

Active testing was begun and the preliminary stages of the investigation were recently completed. In the meantime, there have been many inquiries for information and the bureau has explained that a printed report will be issued at the earliest possible moment. According to George S. Rice, chief mining engineer of the bureau, the principal findings of the bureau are that "strictly speaking there is no spontaneous combustion, but in all cases where sufficient data have been obtained, the oxygen has been used in conjunction with a torch for welding or cutting, and the flame has flashed back through the mixture. It is possible that ignition may occur by a jet of oxygen playing on a carbonaceous material under certtain special conditions; nevertheless, these conditions are most unusual as in many experimental tests made by the bureau the jet could not be so arranged as to cause ignition, although there was a rise of temperature at a certain point and cooling due to expansion at a point beyond.

"In all cases, however, the real danger is in the hydro-gen getting into the oxygen, and it has been found that this is due to improper design in the manufacturing apparatus, *i.e.*, the cells and electrical connections; to insufficient safeguards connected with the electric apparatus, the polarity suddenly and unexpectedly shifting; to the manufacture of oxygen without frequent analyses; and to incompetent or ignorant attendants. Unfortunately, certain makers of oxygen manufacturing apparatus have advertised that any laborer can take care of their apparatus. It is believed that the manufacture of electrolytic oxygen can be carried on in a manner to make it entirely safe. In fact, there has to be over 9 per cent of hydrogen with the oxygen to make an explosive mixture. Nevertheless, certain tanks from one batch caused three widely separated explosions in California, killing seven men in all, and an analysis of gas from a tank filled at the same time showed that it contained over 50 per cent of hydrogen."

Use of Rotary Kilns for Calcining Lime

By A. T. Wood

In the past few years a great deal of interest has been taken in the use of rotary kilns for calcining lime, due no doubt, to the many advantages of the rotary kiln over the vertical type.

Very little information is obtainable or published due, no doubt, to the fact that lime manufacturers who are now operating rotary kilns are fully acquainted with its many advantages and they are not desirous of letting information get out to the public as to its real value. They prefer to hold back the information as long as possible.

Following is a general description of a modern calcining plant, including all of the equipment, starting from the quarry to a finished product:

The capacity of the plant is a determining factor as to the proper size machines to be used in the process. Taking as a basis say a 1000 bbl. plant, or over, in twenty-four hours, the quarry should consist of steam shovel of the proper size for handling the proper amount of stone. The size dipper to be determined from quarry conditions, that is, as to how the stone lays and how it breaks under powder or dynamite. From the steam shovel the stone is discharged into side dump cars, usually from 4 to 10 yd. capacity. The cars being drawn to a central point by a locomotive where they are discharged into a large initial crusher. The type of crusher being the one preferable if the quarry conditions cal conditions of the quarry being a determining factor as to which of the three types is best suited, the roll crusher being the one preferable if the quarry conditions permit. After the material passes through the large initial crusher it is elevated to sizing screens, where the material is sized, the rejections passing to smaller crushers for re-crushing. This material is again elevated and sized. After the material is of proper size it is discharged into storage bins where it is available for feeding to rotary kilns.

While at this point the question of sizing material is a very important one, it is however, very easily disposed of. In certain sections of the United States, certain limestones, especially those found in the New England states, are of such a character that sizing is not an important factor. The stone has certain characteristics so that when exposed to temperatures around 650 deg. C. it disintegrates to a point where it is practically uniform in size. However, limestones found in Central and Western states are very hard and dense. This class of limestones, either calcium or magnesian, should be properly sized to secure best results.

From the storage bins where the material has already passed the sizing screens the limestone is fed by a positive feeder to the rotary kilns. The kilns are on a slight inclination, revolving at a very slow speed, similar to cement kilns, limestone gradually passing through and leaving the discharge end of the kiln in an oxide state, entering the rotary coolers which are also on a slight inclination where the oxide lime is cooled and from the coolers discharging on to conveyors where the material is conveyed to steel or concrete storage tanks. From the storage tanks the material is ready for shipment, either in bulk or placed in barrels or conveyed to hydrating plant, where it may be hydrated and made ready for shipment.

Kilns.—Rotary kilns may be secured from 2 ft. to 12 ft. in diameter and from 10 ft. to 210 ft. in length on two carrying mechanisms. The standard proportions of rotary kilns are 17½ ft. of length per 1 ft. diameter. In some cases this limit may be exceeded. Rotary kilns are in all cases lined with fire brick. The hot zone or the discharge end is lined with 9-in. brick, while the upper or cool end contains 6-in. and 4-in. brick.

Coolers.—Coolers are similar to the kilns in appearance, but contain no lining. They are, however, fitted with lifters so as to lift the material dropping same through space where it has a chance to come in contact with the cool air which is passing through the cooler while being pre-heated for combustion.

Fuel.—Producer gas, natural gas, oil or pulverized coal may be used in rotary kilns for calcining lime. With the exception of pulverized coal any of the above fuels may be used for producing the highest grades of finishing lime, the choice being the one that is the cheapest to secure.

For producer gas work any good grade of bituminous gas coal may be used, the following analysis being one of excellent grade: Vol. matter, 34.78; carbon, 60.57; ash, 3.84; sulphur, 0.81; B.t.u., 14,590.

The average natural gas would have analysis as follows: CO_2, 0.29; O, 0.30; C_2H_4, 1.04; CO, 0.60; CH_4, 93.57; H, 1.40; N, 2.80.

The average analysis of oil gas will be found as follows: CO_2, 0.90; O, —; C_2H_4, 17.40; CO, —; CH_4, 58.30; H, 23.40; N, —.

The use of pulverized coal is not advisable where the highest grades of commercial lime are required. This is due to the fact that in pulverizing the coal there will always be found small particles which are not entirely pulverized which when blown into the burning zone of the kiln, being heavier and larger, do not immediately undergo complete combustion but drop to the bottom of the kiln, and mix with the product where it is carried along with the oxide of lime. These small specks of carbon or ash do not make their appearance until the oxide of lime is being used as hydrate or finishing plasters. At this point the ash or carbon which has been deposited, due to the use of pulverized fuel, appears in the hydrate or finishing plasters in black specks. The pulverized fuel, however, may be used equally as well as the other fuels except in the above case.

Power.—Power to operate rotary kilns when used for calcining lime may be either mechanical or electrical. An electrically driven plant has many advantages over the mechanically driven plant. Engines with the highest efficiency should be chosen. Motors of ample power for continuous hard service should also be considered. Boilers of ample capacity for continuous operation, as well as a spare unit for emergency purposes due to continuous operation should also be considered.

Advantages.—The following advantages are claimed for the use of a rotary kiln for calcining lime: A more uniform product is obtained. The fuel cost per ton of lime is decreased. The repair cost of linings per ton of lime manufactured is decreased. The output is increased. The labor costs are reduced. Quicker results are obtained. All classes of limestones or by-products may be calcined. Quarry spalls are done away with, also no draught troubles and back-fire troubles. The material is in better shape for hydrating purposes. The process is under absolute control at all times.

Milwaukee, Wis.

A New Rust-Proofing Material and Process

The most generally used methods for covering iron and steel with non-rusting metals are based on dipping the articles into molten baths of the protective metals. The best known are leading, tinning and galvanizing, as either lead, tin or zinc are used. In all such processes there is a very considerable loss of the coating metals due to the oxidizing of the molten metal bath.

In our Jan. 1, 1917, issue attention was called to a new coating process in an article by Henry Hess of Philadelphia, Pa. The process originated in Germany and utilizes finely divided zinc or other metals or alloys mixed with a liquid medium. This material, known as "epicassit," is applied cold with a brush and then heated slightly above the melting point of zinc. It is claimed that oxidation losses are avoided by the use of this material, and that the process may be carried out not only on an extensive manufacturing scale, but also on a job involving only a few square inches or the repair of a damaged coating.

The powdered metal, usually either tin, lead, zinc or their alloys, are mixed with a suitable fluxing carrier to the consistency of a smooth, creamy paint. This is evenly coated on the well cleaned article. Heat is then applied to melt the coat down. Details will vary with the nature of the article to be coated. The cold paint may be applied with the brush, just like ordinary paint, or the article may be dipped into the cold bath, or it may be drawn through it, or tumbled in it. The heat may be applied in whatever way is most convenient; the cold painted articles may be placed on shelves or on racks in an oven, more or less similar to an enameling oven; small articles may be placed in heated tumblers that are stationary, until the coating is melted down and are then tumbled to prevent sticking. Other articles are carried through a cold bath of the material on conveyors and discharged onto slightly inclined coarse seive shakers where superfluous material is first shaken off and gathered again for re-use; in their further travel the articles pass through a heated zone in which the coating is melted down and sticking prevented by the shaking of the carrier; the final discharge is into water or a tumbler with polishing material, as sawdust, etc.

Instead of drawing wire through a hot bath, with its many incidental losses and inconveniences, the wire is drawn through a cold bath of "epicassit" or this is applied by rotating brushes or a spray; in its further progress the wire passes through an externally heated tube of uniform temperature and onto a reel, making the process continuous.

Tanks, etc., that are built up of leaded or galvanized sheets and are too large to be dipped are rustproofed where exposed by erecting machinery, such as punching, riveting, etc. In this case "epicassit" is locally applied with a brush and melted on with a suitable torch.

The process and product are covered by U. S. patents which have been acquired by Mr. Hess, Witherspoon Building, Philadelphia, Pa., and licenses are granted to use the process. The material itself is handled by Hess & Son, 1033 Chestnut Street, Philadelphia.

A Stoneware Atomizing Nozzle for Acid Chambers

There are a number of plants manufacturing sulphuric acid which inject water, instead of steam, into their chambers. This method has been found particularly beneficial during the hot summer months when steam of course would not condense readily, whereas when operating with water sprays, the water is atomized to a mist, and as the chambers are usually located in a building, and enclosed otherwise in themselves, there is little likelihood of the freezing question coming up even in the Northern States, although most of the plants are located in the Southern States.

The injection of water into the chambers in a mist-like form or fog, is done simply by putting the water
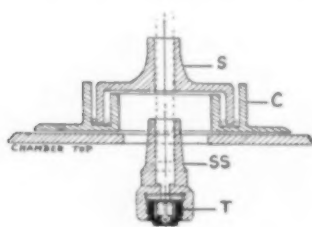

FIG. 1—ARRANGEMENT
OF NOZZLE

under pressure and distributing it in the chambers at the top. The arrangement of connecting and supporting the spray nozzle is shown in Fig. 1.

Most plants are equipped with either glass or platinum sprays, and in the case of glass sprays there is considerable breakage, due to sudden change in temperature, and the platinum sprays are very costly, especially at present. The Monarch Manufacturing Works, 1910

FIG. 2—NOZZLE
PARTS

North Camac Street, Philadelphia, Pa., have taken up the manufacture of a patented nozzle and are making it of stoneware—the whole of the tip (shown at T in Fig. 1), being made of stoneware. They claim that this nozzle will fit directly into the usual lead sockets (SS Fig. 1) in which at present either glass or platinum are used, thereby not necessitating the replacement of the lead socket SS as well; also that due to this new construction, which has been patented, they are able to operate with one-half the pressure at which such atomizing nozzles are usually operated, and give equal capacity and the finest possible atomization of the water, with capacities ranging from 2.5 gallons of water per hour per nozzle up to about 20 gallons per hour.

From Fig. 1 it will be seen that the threaded stoneware part T, has an inner part which fits loosely into the threaded part. Water is prevented from passing around the outside of the inner part by means of a rubber washer as shown, thereby necessitating that the water travel directly into the canal in the inner part, which inner part is made with a projection extending up into the outer stoneware part. Holes are drilled into this neck at such an angle as to give the water a centrifugal motion, thereby enabling it to emit from the orifice of the outer stoneware part in an atomized form. The reason given for this nozzle operating at such low pressures is because the liquid has such a comparatively small length of travel through a restricted area.

The inner stoneware part does not move when the nozzle is in operation—the water simply passes out the orifices which are drilled at a predetermined angle as above explained.

Cleaning of these tips, when required, is made easy because immediately the outer threaded tip is removed from the lead socket, the inner stoneware part, being loose-fitting, will drop out.

This nozzle is also claimed by the manufacturers to retain its spraying qualities indefinitely, because both parts are made of an exceptionally hard close-grained stoneware, wear on which is practically nil. The shoulders prevent of its being reinserted too far towards the orifice of the outer part when the inner part is removed for cleaning. It is claimed, therefore, that the nozzle must always give identically the same spray as originally, regardless of the number of times the inner part is removed for cleaning. Nozzles which require the inner part made of lead, however, necessarily produce a different quality spray every time the inner part is removed, because, due to its construction, must be hammered in sufficiently tight to make a seal around the threads of the inner part (spiral) the full length of the outer threaded tip, and the water travelling this full length through a restricted area, is said to be the cause for requiring double the operating pressure.

Growth of Mellon Institute.—The first Industrial Fellowship at the University of Pittsburgh was established in March, 1911, by a baking company in the Department of Industrial Research, now known as the Mellon Institute of the University of Pittsburgh. In the six years which have elapsed sixty-four distinct concerns have endowed some 147 one-year Industrial Fellowships for the study of problems in which they were interested. The following table shows the number of Industrial Fellowships which have been founded from March to March of each year—1911 to 1917; the number of researchers or Industrial Fellows as they are called, who have been employed on these Fellowships, and the total amounts of money contributed for their maintenance by industrial concerns:

March to March	Number of Fellowships	Number of Fellows	Amounts Contributed
1911-1912	11	24	$39,700
1912-1913	16	30	54,300
1913-1914	21	37	78,400
1914-1915	21	32	61,200
1915-1916	36	63	126,800
1916-1917	42	65	149,100

The total amount of money contributed by industrial firms to the institute for the six years ending March 1, 1917, was $509,500. In addition to this sum, over $350,000 was expended by these concerns in the construction of experimental plants. During the six years the institute itself expended about $230,000 in taking care of the overhead expenses in connection with the operation of the Fellowships. Besides this amount the building and permanent equipment of the institute, which make it the most complete and modern industrial experiment station in the country, represent an investment of about $350,000. Apart from the fact that the results obtained under the Industrial Fellowship system at the Mellon Institute have justified the expenditure of the sums of money mentioned above, it is interesting to note that the success of the Fellowships has encouraged manufacturing organizations to establish well-equipped research departments of their own. Then, too, it has given a new impetus to industrial research work on the part of institutions of learning both in this country and abroad. Through the Industrial Fellowship system, these institutions have found a way to forward the progress of industry and at the same time add to the sum of human knowledge.

Detroit Meeting of American Electrochemical Society

The thirty-first general meeting of the American Electrochemical Society will be held in Detroit, Mich., from Wednesday, May 2, to Saturday, May 5, inclusive. The following attractive program, subject to revision, has been arranged:

Wednesday, May 2—Afternoon: Official visits to automobile plants—Dodge, Packard, Hudson.

Wednesday, May 2—Evening: "Get together" subscription roadhouse dinner, members of American Electrochemical Society, Society Automobile Engineers, A. I. E. E., Detroit Engineering Society.

Thursday, May 3—Morning session: Electric Steel—Its manufacture, uses, advantages and heat treatment; abrasives; ferro-alloys.

Thursday, May 3—Afternoon session: General Electrochemical papers.

Thursday, May 3—Evening: Smoker.

Friday, May 4—Morning session: Melting of nonferrous metals; also various low temperature electrothermic processes.

Friday, May 4—Afternoon: Visits—electric steel plants, powerhouses, etc. Lake Shore drive.

Friday, May 4—Evening: Presidential address; address by Mr. Alex Dow.

Saturday, May 5—Morning session: Electro-deposition of metals; rust prevention. Miscellaneous papers.

Arrangements can be made for groups to visit the Ford or other plants, at any time, by application to the entertainment committee.

Ladies entertainment—Thursday, May 3—Afternoon: Lake Shore drive; tea at Belle Isle or Detroit Athletic Club; on Thursday, May 3, evening, theatre party, and on Friday, May 4, afternoon, drive through Bloomfield Hills, tea at Bloomfield Hills Golf Club. Conveyances and guides for shopping trips at any time by application to the entertainment committee.

The program of papers will be published in our next issue.

New Engineering Society Organized in Southwest

At a convention held in El Paso, Tex., on March 8, 9 and 10 the Southwestern Society of Engineers was organized with more than one hundred charter members. Membership is open to civil, mechanical, mining, electrical or chemical engineers, or architects or other persons belonging to a technical profession, who are not less than twenty-seven years of age, and who have been in active practice of their profession for at least six years. Provision is also made for associated, honorary and affiliated members.

The great distance from centers of population makes it difficult for southwestern engineers to attend meetings of the national engineering organizations, so it is believed that the new society will fill a real need. It is planned to hold at least two conventions of the society each year for the reading and discussion of professional papers and for social intercourse.

At the first convention the following papers were read and discussed:

"The Purpose of Engineering Education," by Dean G. M. Butler, College of Mines and Engineering, University of Arizona.

"Some Lessons Taught the Mining Industry of the Southwest by Present Activities and Prices," by Gerald Sherman, Mine Superintendent of the Copper Queen Consolidated Mining Company, Bisbee, Ariz.

"Modern Highways and the Dividends They Pay," by J. L. Campbell, chief engineer of the E. P. & S. W. R. R.

"Engineering and National Defense," by Lieut. Col. M. L. Walker, Corps of Engineers, U. S. Army, chief engineer of the recent punitive expedition into Mexico.

The officers of the society are:

President, Dean A. F. Barnes, School of Engineering, New Mexico College of Agriculture and Mechanic Arts.

Vice-president for two-year term, Dean G. M. Butler, College of Mines and Engineering, University of Arizona.

Vice-president for one-year term, Dean S. H. Worrell, Texas College of Mines.

Secretary, Forrest E. Baker, El Paso, Tex.

Treasurer, R. W. Goddard, Professor Electrical Engineering, N. M. College of Agriculture and Mechanic Arts.

Director for three-year term, S. O. Andros, Albuquerque, N. M.

Director for two-year term, J. N. Gladding, city engineer, El Paso, Tex.

Director for two-year term, D. B. Gillies, general manager Carrigan-McKinney & Company, Chihuahua.

Director for one-year term, J. C. Ryan, county engineer, Cochise County, Arizona.

Director for one-year term, W. E. Robertson, El Paso, Tex.

Kansas City Meeting of American Chemical Society

Active preparations for the Spring meeting of the American Chemical Society, which will be held in and around Kansas City, Mo., during the week of April 9 are being made by local committees of which the following are chairmen.

Executive.—W. A. Whitaker, Lawrence, Kan.

Finance.—R. Hirsch, Kansas City, Mo.

Reception and Registration.—L. E. Sayre, Lawrence, Kan.

Smoker.—G. H. Clay, Kansas City, Kan.

Banquet.—Roy Cross, Kansas City, Mo.

Publicity.—F. B. Dains, Lawrence, Kan.

Excursions.—C. F. Gustafson, Kansas City, Kan.

Entertainment of Ladies.—Mrs. F. B. Dains, Lawrence, Kan.

The headquarters will be at the Hotel Muehlebach, corner Twelfth and Broadway Streets. In addition to the regular general and divisional meetings, smoker and banquet, interesting excursions are being arranged to the following industrial plants: Packing houses, flour mills and other foodstuffs factories, zinc smelters, acids, cement, paper, soap and structural steel factories and a petroleum refinery. The University of Kansas at Lawrence will also be visited.

Personal

Prof. **W. D. Bancroft** has been selected by the American Electrochemical Society to represent electrochemistry on the Chemistry Committee of the National Research Council. The Board has also pledged the Society to co-operate with this committee in aiding the cause of electrochemical research in the country.

Dr. **John H. Banks** of the late firm of Ricketts & Banks, announces that his son, **Harold P. Banks**, has been taken into partnership. The address of the new firm of John H. Banks & Son will remain at 61 Broadway, New York.

Mr. **Emile J. Bayle**, assistant to the president of the Pfaudler Company, Rochester, N. Y., gave an address before the Rochester Engineering Society on March 2 on "Profit-Making Management."

Mr. C. Bramson, formerly chemist with the Provident Chemical Works is now connected with the Superior Phosphate Company, in Illinois.

Mr. C. F. Carrier, Jr., who was general superintendent of the Warner-Klipstein Chemical Company, during the construction and starting of their new plant at South Charleston, W. Va., has recently accepted a position as department manager and chemical engineer with the Rollin Chemical Company, Inc., who are the largest manufacturers of barium chemicals in the United States. He will have charge of the chemical engineering connected with extensive additions which are being made to their plant at Charleston, W. Va.

Prof. W. J. Crook has resigned from the South Dakota State School of Mines to re-enter the employ of the Pacific Coast Steel Company at South San Francisco. He will take up his duties there about April 1. He was chief chemist at these works prior to his appointment at the mining school in 1913.

Mr. Samuel F. Eldridge, formerly connected with the Columbus Iron & Steel Company, Columbus, Ohio, as engineer, has been appointed special agent of the American Rolling Mill Company, Middleton, Ohio, owing to the consolidation of the above companies under the latter name.

Mr. Arthur I. Jacobs, who for seventeen years was in charge of the water and electric light departments of the city of St. Louis, has joined the research department of the Powdered Coal Engineering and Equipment Company of Chicago.

Mr. F. A. Kennedy has resigned as a member of the instructing staff of the mining and metallurgy department of the University of Wisconsin, and is now consulting engineer with John A. Savage, Duluth, Minn.

Mr. Charles Of recently returned from Cuba, where he was in charge of the mining operations of the Davison Chemical Company.

Mr. Louis S. Potsdamer has come to New York from Sweetwater, Tenn., to take up new duties with Messrs. Toch Bros. He was acting treasurer of the Durex Chemical Works at Sweetwater.

Mr. J. L. Replogle has been elected president of the American Vanadium Company, Pittsburgh, Pa., succeeding James J. Flannery, who becomes chairman of the Board of Directors. Mr. Replogle was formerly vice-president and general sales manager.

Mr. Kirby Thomas has been spending several weeks in Brazil. He is expected to return in a short time.

Mr. Howard F. Weiss, whose resignation as director of the Forest Products Laboratory of the United States Forest Service takes effect April 1, will become associated with the C. F. Burgess Laboratories, Madison, Wis., for consulting, experimental and development work in chemical engineering lines. Mr. Weiss will have direction of the division relating to wood products.

CURRENT MARKET REPORTS

The Iron and Steel Market

The steel market in the past fortnight has presented the appearance of having been sold to a standstill, the turnover being confined very largely to the making of contracts with regular mill customers for additional delivery periods. There was increased disposition to buy, on the part of some consumers, by reason of fear that steel furnished the United States Government on rush orders would reduce deliveries to the regular domestic trade.

The volume of government business placed cannot be estimated, but it is known that a number of rush orders have been placed, and in many instances rolling was undertaken at once, previously arranged rolling schedules being dropped when the authorities expressed a desire that the steel be furnished at the earliest possible time.

While the requirements of the government are large in its program of preparing for war, the relation between the tonnage and the total capacity of the industry may easily be overrated. The steel productive capacity of all the present belligerents, at the time the war started, was approximately 43,000,000 tons, measured in steel ingots, while the United States now has a capacity of approximately 45,000,000 tons, so that what is a large tonnage for the belligerents on either side, for war purposes, is a relatively small tonnage for the United States.

While the virtual entrance of the United States into the war has made steel scarcer and the steel market stronger, the prospects for a continuance of the present high prices for steel are not thereby prolonged, for there is the offset that the participation of the United States may have a moral effect before it has much physical effect, and operate to bring the war to an earlier conclusion than would otherwise have been the case. Finished steel products, for shipment at mill convenience, are held at nearly three times the prices, on an average, that obtained in December, 1914, when the market was at its lowest level since 1898. The excess over the low level is almost four times as great as obtained in 1907, when steel prices were at the highest level attained between 1902 and 1916. It is commonly held in business circles that the end of the war will bring a readjustment in all commodity values. The nonferrous metals are expected to discount the end of the war, and indeed quite recently it was maintained in some quarters that signs of a tendency to discount the war's end were already apparent. The steel mills, however, may find it possible to maintain prices for a time, as they have learned to resist price declines, acting independently and without the meetings that have come to be considered illegal. It must be recognized also that the depreciation of the dollar is not wholly temporary, and that relatively high commodity values are likely to rule for several years after the war.

There is certainly nothing like a consensus of opinion in the iron and steel trade as to what is likely to occur. The common view undoubtedly is that the war will not last beyond the present year, and yet there has been some buying of pig iron for delivery in the first half of 1918, at prices at least as high as have obtained for the second half of this year. This buying has occurred only as to certain districts, notably Virginia and Southern Ohio. There is much valley iron unsold for the second half of this year.

Pig iron prices have been advancing in all markets, an advance of a dollar a ton frequently occurring overnight. The averaging price is now approximately $35 a ton at furnace, or very nearly three times the price two years ago, when the market was at its lowest point since 1904.

Finished-steel price advances in the past fortnight have been relatively unimportant, the very large advances in the fore part of March having apparently equalized with the influences at work. Billets are higher, at $70 to $75.

Transportation conditions have been improving, although slowly, and production increases slowly, while shipments have increased somewhat more rapidly, and mills are now making inroads in the stocks accumulated during the winter.

Non-Ferrous Metal Market

Saturday, March 24.—The copper market has been dull but has remained firm. Tin has advanced following an advance abroad, while spelter remains virtually unchanged. Lead is also unchanged. Antimony is scarce and has again advanced. Silver has taken a slight drop.

Copper.—The situation in this market has been very dull. Offerings were freer for second quarter about the middle of March. A strike at the Nichols Copper Company's Laurel Hill refinery started on the 16th and lasted about a week. Shipments were curtailed during the strike. Some of the producers have offered to sell copper to the Government at half price, and over 45,000,000 lb. was taken at a little below 16¾c.

Tin.—On the 15th there developed a strong demand for tin in London which advanced the market there and likewise here. From 53.25 on the 15th, Straits tin has risen to 56.25. Arrivals so far this month only total 1585 tons but there is considerable tin afloat. Banca tin is scarce but there has been some sales of No. 1 Chinese at 45c. for April delivery.

Lead.—The lead market has been quiet, and the trust price remains at 9.00 cents, New York, with independents asking 9.87½.

Spelter.—This market has remained firm in spite of the continued poor consuming demand. The price remains virtually unchanged at 10.80 to 10.92½ New York for spot.

Other Metals.—Antimony has been very scarce for spot deliveries. There has been little interest in futures. The price for spot jumped from 32.00c. to 34.00c. on the 20th. Silver has been gradually declining for some time and registered a decline from 73c. on March 15 to 72⅛ on March 23. Aluminium remains at 58.00-60.00c. for No. 1 virgin metal. Magnesium is unchanged at 3.00-3.50; Electrolytic nickel is 0.55c.; cadmium 1.50; quicksilver 120.00; platinum, 105.00; cobalt, 1.70; and tungsten concentrates, 17.00-17.50 per unit.

Chemical Market

Coal Tar Products.—A good volume of business has been transacted during the past two weeks and the outlook from both the producing and selling viewpoint has been decidedly encouraging. Higher prices have as a rule been in force and the general tendency upon the part of manufacturers has been to hold stocks and make consumers pay the piper. *Benzol* and *Toluol* markets have moved in unison and manufacturers have been sitting tight and doling out comparatively small quantities and have been gunning for new business only in a few instances. A few stray cars of benzol have been offered from time to time and these generally reached a buyer quickly when the product measured up to standard specifications. Toluol has been even more firmly held than benzol and but few lots of surplus material have reached the market. *Xylol* is meeting with a wider demand but offerings are heavy and some manufacturers are quoting at a comparatively low figure. *Solvent naphthas* continue to press on the market but producers have been studying possibilities of new sources of consumption and it is stated that considerable quantities have now found their way into industries that have heretofore used petroleum products.

Aniline oil continues firm. Some of the former producers who dropped out when prices did not allow of a profit have inaugurated a new production but this so far does not appear to have overtaken the demand and there is still difficulty noted in securing stocks for immediate delivery.

The toluol derivatives have come in for special attention during the fortnight and *para toluidine* has been in brisk demand. Manufacturers of inks and dyes have been in the market in a heavy and urgent way. Quotations for this intermediate have advanced sharply and at the moment of writing supplies are centered in one or two hands. *Ortho toluidine* has shared in a degree the firmness of para, but supplies have become more liberal. *Ortho and para nitrotoluol* have experienced a somewhat similar experience and the few producers report important inquiry.

Phenol continues to be the bête noire of the coal tar producers. Prices are low and stocks are more than abundant to answer any needs of the trade. Hopes appear to be centered in possible government buying but so far this has not materialized.

Diphenylamine has been subject to a very heavy demand from explosive manufacturers and offers are now greatly restricted. One of the leading producers has advanced his quotations about 20 per cent.

Glycerine has developed a general undertone of activity and considerable business has passed for both domestic and export account. The movement, of course, has been principally in dynamite grades although C. P. has met with a heavy consuming inquiry.

Arsenic has advanced sharply and Paris Green has been moved up in sympathy. This is a reflection of the usual seasonal demand. *Quicksilver* has been subject to an erratic movement. Spot stocks have been taken up quickly and quotations to arrive on rolling material have been established on a high level.

Caustic soda and soda ash are higher both on spot and contract. There is a very important inquiry noted for 1918 business and as a result of the freight congestion spot lots have not been obtainable at other than fancy prices from day to day. Manufacturers are well sold out for practically all nearby positions. *Bleaching powder* in contrast is off and there is not much demand.

In acids, the high grade *acetics* have been in active demand for foreign accounts and supplies are scarce. Orders for glacial have in some instances gone begging because of the impossibility of securing supplies for immediate shipment. *Nitric acid* which recently advanced sharply has moved somewhat slowly and some business has been taken quietly at reduced prices. The demand has been spasmodic. *Sulphuric acid* has been moving steadily into consumption at quietly firm prices. The high level upon which brimstone is quoted finds reflection in the brimstone acid situation. *Bichromates* are easier and consumers are inclined to hold off. *Borax* and *Epsom salts* have been in such scanty supply that many orders have remained unfilled.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET MARCH 23, 1917.

Acetic anhydride	lb.	$1.75 —	$1.85
Acetone drums	lb.	.23 —	.23½
Acid, acetic, 28 per cent	lb.	.04 —	.04½
Acetic, 56 per cent	lb.	.08 —	.09½
Acetic, glacial, 99½ per cent carboys	lb.	.25 —	.27
Boric, crystals	lb.	.10½ —	.11
Citric, crystals	lb.	.73 —	.73½
Hydrochloric, commercial, 18 deg.	lb.	.01⅜ —	.01½
Hydrochloric, 20 deg.	lb.	.01½ —	.01⅝
Hydrochloric, C. P., conc., 22 deg.	lb.	.01¾ —	.01⅞
Hydrofluoric, 30 per cent, in barrels	lb.	.04¾ —	.05
Lactic, 44 per cent.	lb.	.10½ —	.12
Lactic, 22 per cent	lb.	.05 —	.05½
Nitric, 36 deg.	lb.	.05 —	.05¼
Nitric, 42 deg.	lb.	.06½ —	.07
Oxalic, crystals	lb.	.45 —	.46
Phosphoric, 85 per cent	lb.	.28 —	.30
Picric	lb.	.70 —	.80
Pyrogallic, resublimed	lb.	3.50 —	....
Sulphuric, 60 deg. (brimstone)	ton	18.00 —	20.00
Sulphuric, 66 deg.	ton	29.00 —	30.00
Sulphuric, oleum (Fuming), tank cars	ton	34.00 —	35.00
Tannic, U. S. P. bulk	lb.	.45 —	.50
Tartaric, crystals	lb.	.83 —	.85
Alcohol, grain, 188 proof	gal.	2.62 —	2.64
Alcohol, wood, 95 per cent	gal.	.90 —	.92
Alcohol, denatured, 180 proof	gal.	.65 —	.66
Alum, ammonia lump	lb.	.04 —	.04½
Alum, chrome ammonium	lb.	.18 —	.20
Alum, chrome potassium	lb.	.30 —	.35
Alum, chrome sodium	lb.	.22 —	.23
Alum, potash lump	lb.	.05½ —	.06

Aluminium sulphate, technical	lb.	.01⅞ —	.02
Aluminium sulphate, iron free	lb.	.03¼ —	.03½
Ammonia aqua, 26 deg. carboys	lb.	.05¼ —	.05¾
Ammonium carbonate	lb.	.10½ —	.11½
Ammonium nitrate	lb.	.14 —	.14½
Ammonium, sulphate domestic	lb.	.04⅞ —	.05
Amyl acetate	gal.	3.50 —	4.00
Arsenic, white	lb.	.17 —	.18
Arsenic, red	lb.	.30 —	.60
Barium chloride	ton	90.00 —	95.00
Barium sulphate (Blanc Fixe) powder	lb.	.04 —	.04½
Barium nitrate	lb.	.11 —	.11½
Barium peroxide basis 70 per cent	lb.	.27 —	.29
Bleaching powder 35 per cent chlorine	lb.	.03½ —	.03¾
Borax, crystals, sacks	lb.	.07¾ —	.08
Brimstone, crude	ton	45.00 —	
Bromine, technical	lb.	1.30 —	1.35
Calcium, acetate, crude	lb.	.03 —	.03½
Calcium, carbide	ton	80.00 —	90.00
Calcium chloride, 70-75 per cent, fused, lump	ton	26.00 —	
Calcium peroxide	lb.	1.70 —	1.75
Calcium phosphate	lb.	.30 —	.33
Calcium sulphate	lb.	.01¼ —	.01½
Carbon bisulphide	lb.	.04 —	.04½
Carbon tetrachloride, drums	lb.	.16¼ —	.16¾
Caustic potash, 82-92 per cent	lb.	.78 —	.80
Caustic soda, 75 per cent	lb.	.04⅜ —	.04½
Chlorine, liquid	lb.	.15 —	.16¼
Copperas	100 lb.	1.00 —	1.15
Copper carbonate	lb.	.33 —	.35
Copper cyanide	lb.	.70 —	...
Copper sulphate, 99 per cent, large crystals	lb.	.09 —	.09½
Cream of tartar, crystals	lb.	.43 —	.43½
Epsom salt, bags	100 lb.	3.75 —	4.00
Formaldehyde, 40 per cent	lb.	.13½ —	.13¾
Glauber's salt	100 lb.	.60 —	.65
Glycerine, bulk, C. P.	lb.	.54 —	.55
Iodine, resublimed	lb.	3.50 —	3.55
Iron oxide	lb.	.02 —	.08
Lead acetate, white crystals	lb.	.14 —	.14½
Lead arsenate	lb.	.10 —	.10½
Lead nitrate	lb.	.16½ —	.17
Litharge, American	lb.	.08½ —	.10
Lithium carbonate	lb.	1.02 —	1.03
Manganese dioxide	lb.	.60 —	.65
Magnesium carbonate, tech.	lb.	.24 —	.26
Nickel, salt, single	lb.	.14 —	.14½
Nickel, salt, double	lb.	.11 —	.11½
Phosphorous, red	lb.	1.10 —	1.20
Phosphorus, yellow	lb.	.85 —	.90
Potassium bichromate	lb.	.36 —	.38
Potassium bromide granular	lb.	1.00 —	1.01
Potassium carbonate calcined, 80-85 per cent	lb.	.32 —	.45
Potassium chlorate, crystals	lb.	.58 —	.60
Potassium cyanide, 98-99 per cent	lb.	1.85 —	1.90
Potassium iodide	lb.	2.90 —	2.92
Potassium muriate 80-85 p. c. basis of 80 p. c	ton	400.00 —	415.00
Potassium nitrate	lb.	.29 —	.31
Potassium permanganate	lb.	3.50 —	3.75
Potassium prussiate, red	lb.	2.50 —	2.75
Potassium prussiate, yellow	lb.	.90 —	.91
Potassium sulphate, 90-95 p.c. basis 90 p.c.	ton	275.00 —	280.00
Rochelle salts	lb.	.36 —	.36½
Sal ammoniac, gray gran.	lb.	.11 —	.12
Sal ammoniac, white gran.	lb.	.18 —	.18½
Sal soda	100 lb.	1.10 —	1.15
Salt cake	100 lb.	.95 —	1.05
Silver cyanide	oz.	.70 —	...
Silver nitrate	oz.	.47¾ —	...
Soda ash, 58 per cent, light, flat	lb.	.03¼ —	.03⅜
Soda ash, 58 per cent, dense, flat	lb.	.035 —	.036
Sodium acetate	lb.	.09 —	.10
Sodium benzoate	lb.	6.50 —	7.00
Sodium bicarbonate, domestic	100 lb.	1.90 —	2.00
Sodium bichromate	lb.	.16½ —	.17
Sodium bisulphite, powd.	lb.	.04½ —	.05
Sodium chlorate	lb.	.25 —	.26
Sodium cyanide	lb.	1.05 —	1.10
Sodium fluoride, commercial	lb.	.11¾ —	.12
Sodium hyposulphite	lb.	.01⅝ —	.02
Sodium nitrate, refined	lb.	.05¼ —	.05½
Sodium nitrite	lb.	.14 —	.15
Sodium peroxide	lb.	1.00 —	1.10
Sodium phosphate (tri)	lb.	.04½ —	.05
Sodium prussiate, yellow	lb.	.31 —	.32
Sodium silicate, liquid, 40 deg.	100 lb.	1.05 —	1.25
Sodium sulphide, 30 per cent crytals	lb.	.03 —	.03¼
Sodium sulphide, 60 per cent, fused	lb.	... —	...
Sodium sulphite	lb.	.03¼ —	.03½
Strontium nitrate	lb.	.25 —	.28
Sulphur chloride, drums	lb.	.09¾ —	.10
Sulphur, dioxide, liquid, in cylinders	lb.	.11½ —	
Sulphur, flowers, sublimed	100 lb.	2.55 —	2.60
Sulphur, roll	100 lb.	2.15 —	2.20
Sulphur, crude	ton	45.00 —	...
Tin bichloride, 50 deg.	lb.	.13½ —	...
Tin oxide	lb.	.54 —	.55
Zinc carbonate	lb.	.24 —	.26
Zinc chloride	lb.	.16 —	.17
Zinc cyanide	lb.	.50 —	...
Zinc dust	lb.	.18 —	.19
Zinc oxide, American process, XX	lb.	.11½ —	.12
Zinc sulphate	lb.	.06½ —	.07

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.58 —	.60
Benzol, 90 per cent	gal.	.58 —	.60
Toluol, pure, water white	gal.	1.80 —	1.90
Xylol, pure, water white	gal.	1.00 —	1.25
Solvent naphtha, water white	gal.	.20 —	.22
Solvent naphtha, crude heavy	gal.	.15 —	.18
Creosote oil, 25 per cent	gal.	.30 —	.32
Dip oil, 20 per cent	gal.	.26 —	.30
Pitch, various grades	ton	8.00 —	20.00
Carbolic acid, crude, 95-97 per cent	lb.	.90 —	.95
Carbolic acid, crude, 50 per cent	lb.	.50 —	.60
Carbolic acid, crude, 25 per cent	lb.	.28 —	.30

Intermediates, Etc.

Alpha naphthylamine	lb.	1.10 —	1.25
Aniline oil	lb.	.27½ —	.28
Aniline salts	lb.	.29 —	.31
Anthracene, 80 per cent	lb.	.10 —	
Benzaldehyde	lb.	4.00 —	4.50
Benzidine, base	lb.	1.85 —	2.00
Benzidine sulphate	lb.	1.50 —	1.60
Benzoic acid	lb.	7.50 —	8.00
Beta Naphthol, sublimed	lb.	.80 —	.85
Dinitrochlor benzol	lb.	.47 —	.50
Dimethylaniline	lb.	.56 —	.60
Diphenylamine	lb.	.90 —	1.00
H-Acid	lb.	Nominal	
Metaphenylenediamine	lb.	1.35 —	1.50
Monochlorbenzol	lb.	.34 —	.35
Naphthalene, flake	lb.	.09½ —	.09¾
Naphthionic acid, crude	lb.	1.75 —	2.00
Nitro naphthalin	lb.	.45 —	.55
Ortho-toluidine	lb.	1.25 —	1.30
Para-amidophenol base	lb.	3.75 —	4.00
Paranitraniline	lb.	1.20 —	1.25
Paraphenylenediamine	lb.	3.50 —	3.75
Para toluidine	lb.	2.00 —	2.10
Phenol, U. S. P.	lb.	.43 —	.44
Resorcin, technical	lb.	9.00 —	...
Resorcin, pure	lb.	16.50 —	17.00
Salicylic acid	lb.	.80 —	.85
Salol	lb.	1.40 —	1.50
Sulphanilic acid	lb.	.30 —	.32
Tolidin	lb.	3.00 —	...
Toluidine-mixture	lb.	.75 —	.80

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	3.05 —	
Corning, Ohio	bbl.	2.38 —	
Somerset, Ky.	bbl.	2.18 —	...
Wooster, Ohio	bbl.	2.05 —	...
Indiana	bbl.	1.73 —	
Illinois	bbl.	1.87 —	
Oklahoma and Kansas	bbl.	1.70 —	
Caddo, La., light	bbl.	1.80 —	...
Corsicanna, Tex., light	bbl.	1.70 —	
California	bbl.	.73 —	.82

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.13½ —	.14
Cylinder, light	gal.	.21 —	.26
Cylinder, dark	gal.	.18 —	.19
Extra cold test	gal.	.26 —	.31
Paraffine, high viscosity	gal.	.29½ —	.30
Paraffine, .903 sp. gr.	gal.	.21½ —	.22
Paraffine, .865 sp. gr.	gal.	.18½ —	.19

Flotation Oils

Pine oil, steam distilled	gal.	.59 —	...
Pine oil, destructively distilled	gal.	.47 —	...
Pine-tar oil	gal.	.19 —	...
Pine-tar oil, double refined	gal.	.30 —	...
Pine oil, light	gal.	.37 —	...
Pine oil, heavy	gal.	.26 —	...
Turpentine, crude	gal.	.38 —	...
Pine tar, thin	gal.	.18 —	...
Hardwood oil, f.o.b. Michigan	gal.	.16 —	...
Creosote, coal tar neutral	gal.	.15 —	...
Creosote, coal tar, acid	gal.	.21 —	...

Vegetable and Other Oils

China wood oil	lb.	.13½ —	.15
Cottonseed oil, crude	gal.	.89 —	...
Linseed oil, raw, cars	gal.	1.00 —	...
Peanut oil, crude	gal.	1.00 —	...
Rosin, 280 lb.	bbl.	6.00 —	...
Rosin oil, first run	gal.	.38 —	...
Rosin, oil, fourth run	gal.	.67 —	...
Soya bean oil, Manchuria	lb.	.13 —	...
Turpentine, spirits	gal.	.47½ —	...

Miscellaneous Materials

Barytes, floated, white foreign	ton	38.00 —	40.00
Barytes, floated, white, domestic	ton	25.00 —	35.00
Beeswax, white pure	lb.	.52 —	...
Carnauba wax, highest grade	lb.	.51 —	...
Chalk, light, precipitated, English	lb.	.03 —	.06
Feldspar	ton	8.00 —	12.00
Fuller's earth, powdered	100 lb.	.80 —	1.05
Red lead, dry, carloads	lb.	.10½ —	...
Soapstone	ton	10.00 —	12.50
Talc, American, white	ton	10.00 —	13.00
White lead, dry	lb.	.09¼ —	...

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	Nominal	
Chrome cement, Grecian	net ton	60.00 —	
Clay brick, 1st quality fireclay	per 1000	45.00 —	
Clay brick, second quality	per 1000	30.00 —	
Magnesite, Grecian, dead burned	net ton	... —	90.00
Magnesia brick, Grecian, 9x4½x2½	net ton	... —	140.00
Silica brick	per 1000	... —	45.00

Ferroalloys

Ferro-carbon-titanium, carloads	lb.	.12½ —	
Ferrochromium	lb.	Nominal	
Ferromanganese, domestic, delivered	ton	300.00 —	325.00
Ferromanganese, English	ton	185.00 —	
Ferromolybdenum, per lb. of Mo.	lb.	4.00 —	
Ferrosilicon, 50 per cent carloads del. Pittsburgh	ton	200.00 —	250.00
Ferrosilicon, 50 per cent, contract	ton	100.00 —	
Ferrotungsten, 75-85 per cent, f.o.b Pittsburgh	lb.	1.95 —	
Ferrovanadium f.o.b. works	lb.	2.75 —	3.00

INDUSTRIAL

Financial, Construction and Manufacturers' News

Financial

Archipelago Copper Company, Delaware, has been incorporated with a capital of $2,500,000 to produce copper, gold, zinc, etc. The incorporators are S. L. Howard, L. H. Gunthey, A. W. Britton, all of New York.

The Atlas Steel Casting Company, 1963 Elmwood Avenue, Buffalo, N. Y., has increased its capital from $150,000 to $400,000 for expansion.

The Barrett Company, Philadelphia, Pa., successor to the former American Coal Products Company, has filed notice of increase in its capital stock from $20,000,000 to $37,000,000 for extensions. The new issue will include $10,000,000 in common and $7,500,000 in preferred stocks. William H. Childs is president of the company.

Bernicedale Coal Company, Inc., Binghamton, N. Y., has been incorporated with a capital of $100,000. Business: coal, fuel and petroleum products. The incorporators are L. M. Bissell, E. E. Powell, 43 Orton Avenue, Binghamton.

Bucham Coal, Timber and Mineral Corporation, Delaware, has been incorporated with a capital of $1,000,000 to deal in minerals and oils. The incorporators are F. D. Buck, George W. Dillman, M. L. Horty, Wilmington, Del.

The C. Buhl Textile Engineering Company, 417 Romaine Building, Paterson, N. J., has been incorporated with a capital of $125,000 to manufacture oxygen, nitrogen and chemicals for textile use. The incorporators are C. P. Buhl, A. Crevier and H. L. Duke, all of Paterson.

California Alkali Company, San Francisco, organized for the purpose of constructing and equipping works for the manufacture of soda ash and other alkali products, has been permitted by Commissioner of Corporations H. L. Carnahan to sell 2000 shares of its preferred stock for $200,000 cash and to issue 15,000 shares of its common stock in consideration of the transfer to the company of secret processes and of services rendered in investigation, exploration and promotion of the company. It is estimated approximately $20,000 will be required for the acquisition of a factory site, $130,000 for building and equipment and $50,000 for working capital. The plant is to be constructed on Owens Lake, Inyo County.

Carolina Chemical Works, Cleveland, Tenn., has been incorporated with a capital of $10,000 to deal in potash. The incorporators are A. L. Kirkpatrick, M. J. Shyer, Oscar C. Schwarzenberg and others.

Charleston Chemical Company, Charleston, Tenn., has been incorporated. The incorporators are A. L. Kirkpatrick, Melvin J. Shyer, Oscar C. Schwarzenberg and others, to manufacture potash and by-products.

The Cleveland Brass & Copper Mills of New York has been incorporated with a capital of $1,050,000 to manufacture brass, copper, other metals, etc. The incorporators are H. S. Gould, B. F. Brusstar, S. H. Moore, J. H. Foster, Hydraulic Pressed Steel Company of Cleveland, Ohio.

The Columbia Chemical Construction Company, Philadelphia, Pa., has filed articles of incorporation at Dover, Del., with a capital of $100,000, to manufacture chemicals. Norman Craig, Frederick Snyder and Herbert L. Maris, Philadelphia.

Columbia Dye Works, Inc., New York, has been incorporated with a capital of $50,000 to deal in dyes. The incorporators are B. J. Dowden, W. A. Wilson, H. F. Sawyer, 417 Marlboro Road, Yonkers.

The Crossley Chemical Company, Brooklyn, N. Y., has been incorporated with a capital of $40,000. The incorporators are H. B. Deyo, E. D. Loughman and C. H. Bailey, Elmhurst.

The Detroit Graphite Company declared a stock dividend of 100 per cent on the common and preferred at the annual meeting of stockholders. This dividend, with a cash dividend of 10 per cent declared a few months ago, marks the close of the most prosperous year in the company's history, the gross business being more than double that of the previous year. The company is now capitalized at $600,000, of which $100,000 is preferred. Additions to the factory on Twelfth Street, now under construction, and others authorized by the directors will greatly increase the output during 1917.

The Eastern Copper Company, Brooklyn, N. Y., has been incorporated with a capital of $1,500,000. The incorporators are F. H. Lathrap and J. K. Turner.

Eastern Foundry Supply Company, Boston, Mass., has been incorporated with a capital of $20,000. The incorporators are William T. Nicholson, Providence, R. I., George A. Taher, Boston, and Lester W. Ingram, Boston.

The Edgewater Foundry Company, Edgewater, N. J., has been incorporated with a capital of $10,000 to operate a foundry. Joseph Fuchs, Frederick Butzhah and A. W. Brain, Edgewater, are the incorporators.

The Federal Iron Works, 207 South Second Street, Camden, N. J., has been incorporated with a capital of $10,000 to manufacture iron and steel products. The incorporators are M. A. Testa, J. C. and J. M. Schwartz.

Federal Leather Products, Inc., New York, has been incorporated with a capital of $1,000 to deal in leather and tanning. The incorporators are J. O. Noakes, W. G. Kirk and R. A. Grumm, 60 East Forty-second Street.

The Fiberoid Corporation, Massachusetts, has been incorporated with a capital of $5,700,000 to manufacture pyroxylene and its compounds. The incorporator is Edmund J. Levine, 53 Fifth Avenue, New York City.

Fort Wayne Rolling Mill Company, Fort Wayne, Ind., has been incorporated with a capital of $100,000, increasing to $300,000.

The Fuel Products Corporation, New York, has been incorporated with a capital of $100,000 to deal in fuels, products, distillates. The incorporators are L. F. Criado, F. C. M. Carlsen and A. C. Lowenthal, 171 Hancock Street, Brooklyn.

Gasoline Products Company, 12 Bayview Avenue, New Jersey, has been incorporated with a capital of $350,000 to manufacture by-products of gasoline, kerosene, benzine, oils, greases, etc.

General Gasoline Corporation, New York, has been incorporated with a capital of $175,000 to deal in liquid fuels. The incorporators are W. G. Brown, E. A. Pirscher and F. C. Schussler, 5 West 104th Street.

Glassoclear Corporation, Manhattan, has been incorporated with a capital of $500,000 to manufacture glass, wind shields, auto accessories. The incorporators are L. Frazin, 221 West Ninety-second Street, New York City; J. J. Lazaros, 600 West 115th Street, New York City, and A. S. Klein, 932 Teller Avenue, Bronx.

The suit of a stockholder of Harrison Brothers & Company, Grays Ferry Avenue, Philadelphia, Pa., to restrain the sale of the company to the E. I. du Pont de Nemours Company on the ground that the common stockholders had been accorded preference over the preferred stockholders has been withdrawn (March 19) and agreement reached to consummate the sale. The paint and varnish business of the company is to be acquired for a consideration of $5,700,000, with all outstanding obligations of the company assumed by the purchaser. The sale has been ratified by a vote of 32,513 to 438 shares of company stock.

Construction and Operation

Colorado

DENVER.—The Boulder Tungsten Production Company, which owns 164 acres of tungsten lands, a 50-ton concentrating mill and other apparatus necessary to make concentrates, is planning the erection of a refining plant to make ferro-tungsten. A site has been purchased on the outskirts of the city of Boulder adjoining the Denver, Boulder & Western Railway Company's tracks. Construction on the refinery will commence immediately. Mr. J. G. Clark is president and general manager of the company. Mr. M. M. Rinn is vice president and N. Williams secretary and treasurer.

DENVER.—A company organized under the name of the Colorado Sulphur Products Company plans a factory here for the mining and manufacture of sulphur products. The incorporators are F. C. Ewing, general sales agent of the Crested Butte Anthracite Mining Company; Ronald F. Bulkley of the Western Chemical Company, and James Gredlaitz, an Eastern mining man.

Connecticut

ANSONIA.—The American Brass Company will erect a new factory and foundry building 320 by 98 ft. It will be of brick and steel and will cost about $150,000.

WATERBURY.—The Waterbury Rolling Mills Company has awarded a contract for the construction of three buildings of brick and steel.

Delaware

WILMINGTON.—The Wilmington Leather Company is having plans prepared for a new six-story factory.

Georgia

SAVANNAH.—The Southern Fertilizer and Chemical Company will construct a $50,000 plant for the manufacture of fish oil and scrap. Work will be started immediately on the plant, plans for which were announced sometime ago.

Indiana

ANDERSON. — The Lippincott Glass Company has started its plant at Alexandria. The company has been held up on account of shortage of raw material.

MUNCIE.—The Whitely Malleable Castings Company of this city will rebuild its plant, which was destroyed by fire, at a cost of $300,000.

Kansas

OTTAWA.—A large oil refinery is contemplated here by several oil operators who have producing leases near this site. A. F. Vandersall and W. L. Larkin of Oklahoma City are among those interested.

Louisiana

CEDAR GROVE.—Marine Oil & Refining Company, organized with $500,000 capital, and plans erecting $150,000 refinery with daily capacity 1200 barrels of oil.

SHREVEPORT.—The DeSoto Oil Refining Company, recently reorganized in New York State with a capital of $1,250,000, is considering the erection of a refinery to handle oil from the Louisiana field.

Maryland

FROSTBURG. — A co-operative glass plant will be erected here by a company formed by local parties capitalized at $100,000. The Board of Trade has been active in fostering the project.

Massachusetts

BOSTON.—The Gibby Foundry Company will reopen the plant formerly operated by the Smith & Anthony Company. Light machine castings will be manufactured.

Michigan

MUSKEGON.—The Lakey Foundry and Machine Company has secured permission to erect a $200,000 foundry addition to its local plant. The company manufactures motor castings and machinery.

Missouri

ST. LOUIS.—The Railway Tie Company has acquired four acres in Carondelet as a site for a rolling mill that will employ 300 men.

ST. LOUIS.—The Provident Chemical Company has received building permits for two factory buildings which will cost $47,500.

Montana

ANACONDA.—A large addition will be built to the Washoe sulphuric acid plant which will require 30,000,000 brick.

BUTTE.—The Butte-Detroit mill at the Ophir mine is operating successfully. W. L. Creden is managing director of the company. The old mill has been entirely remodeled and the flotation process installed.

Benefiting by the experiments of the Butte & Superior Company, carried on over a period of two years, Mr. Creden installed the complete and perfectly working plant at the Butte-Detroit in two months. The mill has a present capacity of 200 tons of ore per day, but is receiving only from 70 to 100 tons from the Colorado mine of the Davis-Daly Company. However, more ore will be available soon, and work is now going on to double the capacity of the mill. Later the capacity will be raised to 600 tons. At present but one tube mill is employed, but another has just been received and will soon be added to the plant. At present the ore all comes from the Colorado mine, below the 1000-ft. level, but additional zinc ore is being opened, and arrangements are also being made to take ore from other producers.

The Colorado ore runs 15 per cent zinc, and the concentrates run about 52 per cent and 16 ounces in silver, the average varying slightly from month to month, but for some weeks has been steadily increasing. The recovery is stated to be 94 per cent.

The Ophir was formerly the property of the Butte Central & Boston Company, and when the latter failed many labor claims were unpaid. Foreman I. Davidson and associates, who organized the Butte-Detroit, have paid off every dollar of the labor claims of the Butte Central, and as the result of the installation of the oil flotation system the company is now put on a good financial working and profit producing basis.

Nevada

GOLDFIELD.—The Silver Mines Corporation, which operates the Great Western at Hornsilver, is erecting a 100-ton cyanide mill and is expected to finish it within 90 days. The machinery and equipment for the mill was purchased at Rhyolite and was formerly known as the Sunset cyanide plant. Ore from the Great Western mine at Hornsilver, lying 28 miles south of Goldfield, is ideally adaptable to cyanidation, as was proven from shipments aggregating 4000 tons made a year ago to the big mill at Millers. This ore carried values varying from $18 to $60 a ton, while an average of $30 a ton resulted from the entire lot.

New Jersey

BUTLER.—The new plant of the Berkow Chemical Works, Main Street, recently destroyed by fire prior to entire operation, will be rebuilt. The company proposes to specialize in the manufacture of dyestuffs.

ELIZABETH.—The F. H. Kalbfleisch Company, Baltic Street, Elizabeth, N. J., manufacturer of chemicals, has acquired four acres adjoining its plant, with frontage on the Elizabeth River and the Central Railroad of New Jersey, for the erection of new additions.

JERSEY CITY.—The Goldschmidt Thermit Company, manufacturer of welding apparatus, has purchased fifteen building lots adjoining its plant on Johnston Avenue and Bishop Street for proposed extensions. Plans have been filed for an addition to the plant on Johnston Avenue.

JERSEY CITY.—Joseph Dixon Crucible Company, Monmouth, will erect 3-story addition to present plant on Mercer Street to cost $250,000.

NEWARK.—The Balbach Smelting & Refining Company will build a one-story addition to its plant, 17 x 28 ft., on Avenue R.

NEWARK.—The Elizabethtown Smelting Company has filed plans for a one-story addition to its plant on Frankfort Street.

NEWARK.—The Trautz Company will build a one-story addition, 50 x 84 ft., to its metal refining plant at 10-12 Delancey Street.

NEWARK—An explosion March 16, caused by the failure of a drum of a nitrobenzol machine at the plant of the Chemical Company of America, Westfield Avenue, Springfield, wrecked the building of the company.

NEWARK. — The Butterworth-Judson Company, Newark, N. J., manufacturer of chemicals, has filed plans for the erection of four one-story additions to its plant, each 36 x 60 ft., at Avenue R and the Passaic River. A boiler house, 20 x 33 ft., and other smaller structures will also be erected. The estimated cost is $24,000.

NEWTON.—The Bethlehem Steel Company is arranging for the installation of a large electric crushing plant at its limestone quarries, McAfee Valley, N. J. The plant will have a rated capacity of about 3500 tons per ten-hour day, and is estimated to cost $350,000. The property produces a high-grade calcite for blast furnace and open-hearth service, and the product will be utilized at the company's South Bethlehem works.

PERTH AMBOY. — The Roessler & Hasslacher Chemical Company has commenced the erection of a large addition to its plant at Rector, Commerce and Front Streets. The structure will be three stories, 50 x 100 x 180 ft., brick and rinforced concrete, and will cost about $180,000. The Stone & Webster Engineering Corporation, Boston, has the contract for erection.

PERTH AMBOY.—The United Dyes Corporation has been organized with a capital of $500,000 to take over and operate the plant of the Bothamley Chemical & Extract Company, located on the city dock property on Front Street. The new owners plan for additions and extensions in the present plant. John D. McQuade, Newark, and Edward Mayer are interested in the new corporation.

PERTH AMBOY.—The Raritan Copper Company has awarded a contract for the erection of a one-story addition to its plant to cost about $15,000. The Berlin Construction Company, 220 Broadway, New York City, contractors.

New York

COHOES.—The General Electrical Company of Schenectady has purchased 160 acres in the southern part of Cohoes and will erect a big fibre mill to be operated in connection with the Schenectady shops. Fibre will be made from waste paper and will be used for insulating purposes.

NIAGARA FALLS.—The Niagara Falls Gas & Electric Light Company will build a new generating plant to cost $175,000.

NIAGARA FALLS.—The American Magnesium Corporation, recently incorporated with a capital stock of 2500 shares of $100 par value and 10,000 shares no par value, to carry on business with $600,000, has established a plant at Niagara Falls, N. Y., and is now producing magnesium ingots. I. R. Edmands is president, E. S. Whitney and George O. Seward are vice presidents and D. Burgess is secretary and treasurer.

NIAGARA FALLS.—The Titanium Alloy Mfg. Company, Sugar and Lafayette Streets, Niagara Falls, N. Y., has let contract to the Peckham Construction Company, Mutual Life Building, Niagara Falls, for the erection of additional two-story buildings estimated to cost $75,000.

WATERVLIET.—The Bethlehem Steel Company contemplates building a plant here to manufacture forgings for the Watervliet arsenal.

Ohio

AKRON.—The Akron Foundry Company, 526 Washington Street, will build two large addition to its plant, to cost $18,000.

CINCINNATI.—The John Douglass Company will build an addition to its present plant to cost $50,000. The new building will be used for the manufacture of clay goods.

CLEVELAND.—The Cleveland Brass and Copper Mills Company has let the contract to Westinghouse Church Kerr Company, N. Y., for the erection of foundry buildings. Five buildings will be erected at a total cost of $150,000. Henry C. Osborne of the American Multigraph Company is president of the new concern. B. F. Brewster, formerly general manager of the Michigan Copper & Brass Company, is vice president and general manager.

CLEVELAND. — The Monarch Brass Company, 4613 Payne Avenue, N. E., contemplates the erection of a modern foundry adjoining the site of its present structure.

CLEVELAND.—The Cleveland Brass and Copper Mills Company, a new concern composed of Cleveland men headed by Henry C. Osborne, president of the American Multigraph Company, has let contracts for the erection of five buildings to cost $150,000. It will be the only brass-rolling mill in Ohio.

LORAIN.—The American Sheet and Tinplate Company is seeking additional land for the erection of a large factory to be built in the steel plant district here. Construction work on the sheet and tinplate plant, which will employ 4500 men, is to be started within the next few weeks. It will take three years to complete the plant.

MIDDLETOWN. — The plant of the Miami Iron and Steel Company, which has been idle several years, is being repaired and will be put into operation within the next few months.

SHARON.—Turner-Fricke Gas Engine Company will erect a modern foundry on North Water Street to manufacture materials for the finishing department. All kinds of castings which enter into the manufacture of gas engines will be manufactured.

STEUBENVILLE.—The large paper factory originally built by Hartje Bros. has begun actual manufacturing operations. The plant is one of the largest in this part of the country.

TIFFIN.—Many improvements are being made to the plant of the United States Glass Company, and when finished the capacity of the plant will be increased to such an extent that sixty or seventy-five men will be needed.

URBANIA. — Inability to obtain the necessary coal has postponed the opening of the new glass factory in the buildings formerly owned by the Eagle Glass factory.

YOUNGSTOWN.—Brier Hill Steel Company, which recently purchased the Western Reserve Steel Company and a large site adjoining it, expects eventually to make large improvement conditions to its Western Reserve Works.

Pennsylvania

ALLENTOWN. — The Victor Leather Company will erect a large plant for the tanning of leather of all kinds known as chrome kid leather. Mr. Haddock is president of the company and Samuel J. Kistler is secretary and treasurer. It is claimed that Mr. Haddock has a process whereby he can make any color desired. The goat skins to be used will come from Chican, Cuba and the Latin-America States.

BLACKLICK.—Marshall Foundry Company, here, plans erecting addition to present plant to cost $100,000.

CHESTER.—Scott Paper Company, Seventh and Glenwood Avenues, Philadelphia, plans erecting new branch plant here to cost $500,000. E. I. Scott, president.

CONNELLSVILLE.—The Sligo Iron and Steel Company has been leased to a group of Pittsburgh capitalists who will begin operation shortly turning out bar iron. Eventually it is planned to erect an open-hearth furnace. Joseph McConnell will be general manager of the plant, which has been closed for several years.

HAZARD.—The Alliance Hollow Cement Block Company has commenced the installation of a new crushing plant at its local quarries. The plant will have a capacity of 500 tons of sand daily.

MANHEIM.—Reported United States Asbestos Company plans erecting extensions to double capacity of plant, which now employs about 400 hands. S. R. Zimmerman and Chester L. Hill, Lancaster, owners.

NORRISTOWN.—E. J. Lavino & Company, operating quarry properties at Howellsville, recently purchased, and at Gallagher, Plymouth Township, has acquired the quarries of the Green Lane Trap Rock Company, Green Lake, Perkiomen Valley. It is planned to enlarge and increase the capacity of the plant.

OIL CITY.—A large modern oil refinery will be erected near the mouth of Two Mile Run, a tributary of the Allegheny River. High grade lubricating oils and greases will be manufactured from Franklin heavy crude. H. F. Grant is president of the company. W. A. Edsall is vice-president, and G. W. Black sales manager of the Foco Oil Company of Franklin, Pa., who will have charge of the sales of the many products.

PHILADELPHIA.—The Water Bureau (Carleton E. Davis, chief) has requested an appropriation of $10,000 from the Common Council for the purchase of chlorine for the water department.

PHILADELPHIA.--The General Processing Company, Willard and Trenton Avenues, has filed plans for the rebuilding and improvement of its dyeworks and chemical plant, recently damaged by fire (March 9) with a loss of about $35,000. William C. Foulds is president of the company.

PHILADELPHIA.—The Barrett Chemical Company has awarded a contract for the erection of a one-story addition, 18 x 80 ft., to its plant at Thirty-sixth Street and Gray's Ferry Road, to cost $7,500.

PHILADELPHIA.—Joseph Kopperman & Sons, Florist Street, manufacturers of brass and bronze goods, will build a three-story addition to their plant, about 24 x 32 ft.

PHILADELPHIA.—The Midvale Steel Company has purchased from the Manor Real Estate Company a tract of about seven acres of property on the southwest side of Wissahickon Avenue, for $72,2 0, for proposed extensions to its plant. Plans have been filed for a new machine shop, 65 x 103 ft., to cost about $25,000.

PHILADELPHIA.—Caskey & Keen, Inc., recently organized with a capital of $100,000, has purchased a four-story foundry building at the corner of Sixth and Berks Streets, including property about 135 x 171

ft., for a plant for the manufacture of castings and machinery. William J. Steen is head of the company.

POTTSTOWN.—The Eastern Steel Company is making preparations for the operation of its Warwick mines, Boyerstown, for the production of iron ore for the Pottstown furnaces.

POTTSTOWN.—The Nagle Steel Company is making extensive improvements and betterments in the plant of the Potts Brothers Iron Company, recently acquired. The work will include the installation of new rolling mill machinery, with transfer tables and other equipment.

READING.—The American Boron Products Company, recently organized, is planning for the establishment of a local plant for the manufacture of chemicals. H. O. Miller is president of the company.

SOUTH BETHLEHEM.—The Bethlehem Steel Company has decided to build an eighteen inch and twelve inch mill equipped with traveling tilting tables to roll medium-sized structural shapes, such as angles, beams, channels, etc. After considerable investigation it was decided to install a three-high, eighteen-inch, three-stand mill, equipped with traveling tilting tables, to roll medium-sized structural shapes, such as angles, beams, channels, etc., in order to fill in and lap the smaller sizes of sections rolled on the twenty-eight-inch structural mill. To further round out this situation it was decided to install sixteen-inch and twelve-inch mills to roll the lighter sections of angles, beams, channels, rounds, flats, etc., within the scope of the mill, which consists of six sixteen-inch stands roughing and four twelve-inch stands finishing. The eighteen-inch mill is served by two recuperative furnaces, gravity discharge, using coke oven gas as fuel. This mill is operated by 1500 horsepower, three-phase, twenty-five cycle, 6,600-volt motor; speed ratio, 133 to eighty-one and one-half r.p.m., and 525-horsepower, 220-volt compound wound direct current motor, speed range of 133 to eighty-one and one-half r.p.m., making a direct current and alternating current driving unit, capable of speed range as indicated. The two mills are housed in a building 155 ft. in width by 600 ft. in length, supplemented by a crane runway eighty-five feet span by 250 ft. long, for the handling of billets for heating furnaces. The sixteen-inch and twelve-inch mill, which is housed in the same building, is equipped with run-out table, cooling beds, with center run-out, backed up with duplicate roller straighteners, shears, gauges, weighing and bundling equipment. This mill is served by two 13 x 34-ft. continuous furnaces of the Morgan type, using coke oven gas as fuel. The power for driving this mill is furnished by 2000-horsepower, 6600-volt, 25-cycle alternating current motor with a speed range of 65 to 100 r.p.m.

Rhode Island

PROVIDENCE.—J. C. Culbert will build a factory for refining metal on Mill Street which will be three stories in height, 50 x 100 ft.

Tennessee

CHATTANOOGA.—It is reported that the Franklin H. Kalbfleisch Company will probably build a factory for the manufacture of sulphuric acid in connection with their large chemical plant at North Chattanooga, Tenn.

KNOXVILLE.—The Ocoee Copper Company, recently organized with $1,230,000 capital, will develop several hundred acres of copper ore lands in Polk County. The company was formed by a number of Chattanooga business men. The company will proceed at once to install all the necessary machinery.

Texas

HOUSTON.—The Empire Gas and Fuel Company will erect a large refinery on the 800-acre tract on the Houston ship channel here. A pipe line will bring the oil from the Oklahoma and Kansas fields.

Utah

SALT LAKE CITY.—The Utah Iron and Steel Company plans to spend about $300,000 in extensions to its plant. The company has taken over the location and equipment of the Utah Consolidated Stone Company.

Vermont

MIDDLEBURY.—The Standard Paper Company will begin work on a new building in the spring in the south part of Bellows Falls, where its present plant is located.

Washington

PT. ANGELES.—Two pulp and paper plants will be shortly built in Port Angeles.

The first will be under charge of Whalen Bros. of Canada, who already operate several plants in British Columbia. It will be financed largely by Peabody-Houghteling & Co. of Chicago. Corporate name is Washington Pulp & Paper Co. It is planned to expend $1,750,000 in plant. The site has been secured for $80,000. The capacity will be 120 tons of pulp per day, and the company will also have a newsprint mill and tissue-wrapper paper factory.

The second plant is being put up by Northern Board & Paper Co., of which Chas. H. Myers is manager, 815 White Bldg., Seattle—$500,000 will be spent. The plant will have a capacity of 50 tons of pulp per day.

The Whalen Bros. plant will utilize Sitka spruce and western hemlock and will use the dry sulphide process with several patented features, including giant chippers which take logs from loom, remove back, etc., and chip lock direct, instead of usual process of seasoning short lengths for six to eight months before shredding in the usual manner. The use of hemlock for paper pulp is claimed to be only possible by means of their patented process.

PORT ANGELES.—An experimental plant is being constructed in Port Townsend, Wash., for a series of tests in obtaining by-products from kelp. Mr. Frank Missedat, a German chemist, will have charge of the plant. Kelp beds near Port Townsend will supply material.

SEATTLE.—West Coast Chemical Company, manufacturers of dyestuffs, especially sulphur black, has been expanding rapidly during the past year. The company has also taken up a large manufacture of pharmaceuticals.

VANCOUVER.—The Standard Electric Power and Chemical Company, Vancouver, Wash., has been incorporated by C. D. Charles and John A. Jeffrey, of Portland, Ore., and D. P. Smith, Vancouver, to erect a plant to manufacture nitrates and other chemicals from the air. The company is capitalized at $4,000,000 and owns waterpower sites on the Deschutes River, which will be developed.

TACOMA.—Atlas Foundry Company plans erecting additional buildings to house their industry; cost $60,000.

West Virginia

WHEELING.—It is estimated that the steel and iron mills and furnaces which are being erected by the Whitaker-Glessner Company will cost about $20,000,000. The company has already spent three-fourths of a million dollars for the land and coal deposits in the Beech Bottom Valley. The company has purchased the whole valley covering a distance of a mile and a half in length and a mile wide.

WHEELING.—The Hazel-Atlas Glass Company, principal offices in this city, will double the size of its glass plant at Fetterman, near Grafton. The improvements will include new warehouse, extension to the blow house, enlargement of the power house, installation of four additional gas engines, and a complete pumping station.

WHEELING.—Steel mills and glass factories in this district have resumed operation after a delay due to a shortage of gas.

WHEELING.—Whitaker-Glessner Company, here, will erect steel plant and furnaces in Beech Bottom, Brooks Co., W. Va., to cost about $20,000,000.

Wyoming

CASPER.—The Midwest Oil Company plans to use the casing head gas now wasted at its wells in Salt Creek field. A refinery will be erected in this field to recover gasoline from this gas. The refinery will cost between $50,000 and $100,000.

Canada

AMHERSTBURG, ONT.—Plans being prepared for erecting and work will begin April 1 on plant of Brunner Mond Co. (Gordon S. Rutherford, mgr.), to cost $300,000, for manufacture of alkali products.

HAILEYBURY, ONT.—Riordan Pulp & Paper Company, 1 Beaver Hall Square, plans erecting sulphite plant here to cost $100,000.

HAMILTON, ONT.—Plans being prepared by Prack & Perrine, Hamilton, for erecting and equipping new furnaces, foundry and plant of Carbon & Alloy Steels Co., to cost $300,000. H. J. Waddell, Canadian Drawn Steel Co., mgr.

OCEAN FALLS, B. C.—The large new paper plant of the Pacific Mills Company, Ltd., will be ready for operation about April 15. The company is owned and controlled by the Crown-Willamette Paper Company of Portland, Ore., and is backed

by Portland and San Francisco capital. A second and larger unit will be erected shortly directly across the Link River from the new building. The second unit will have a capacity of 125 tons of paper a day, giving the complete plant a capacity of 225 tons daily. When completed the plant will be one of the largest in the world. Most of the paper made will be news print and Kraft paper made by the sulphate and sulphite process.

SMOOTH ROCK FALLS, ONT.—The Mattagami Pulp and Paper Company, Ltd., a $6,000,000 corporation which was bought in Colorado Springs, Col., is at present constructing a mill at this place which will cost about $2,000,000. It is on the Mattagami River, connected by three miles of spur railway with the National Transcontinental Railway at Smooth Rock Junction. The plant is of modern concrete construction and will be capable of manufacturing 45,000 tons of sulphide pulp annually. Supplementing the factory is a saw mill at the falls with a capacity of 4,000,000 feet, board measure, a year. The plant is so situated that the National Transcontinental Railway furnishes direct outlets to the Atlantic and Pacific seaboards and intermediate markets east and west. Connecting railways include the Temiskaming & Northern Ontario Railway by way of Cochrane to North Bay, and there connecting with the Canadian Pacific and Grand Trunk Railways. On the west the company has outlets over the Algoma Central Railroad by way of Hearst, by way of Michipicoten harbor and Sault St. Marie.

The Mattagami company has practically finished development of a water power with a maximum development of 9,000 horsepower, minimum 1000 horsepower, at the mill site at Smooth Rock Falls. Although this power will be ample for the company's needs for some time to come, it has additional power at Yellow Falls, eight miles above the mill, capable of developing 4,000 horsepower minimum, which will be available for use as the company's business expands. S. R. Armstrong, a pulpwood manufacturer of Pennsylvania, is manager of the company. E. P. Shove, of this city; W. D. Ross, a Toronto banker and steel maker; N. Bruce McKelvie, of Hayden Stone & Co. of New York, and Lieut. Col. D. M. Robertson of Toronto are directors.

TORONTO, ONT.—Queen City Foundry Co. will rebuild plant partially destroyed by fire with loss of $100,000.

Manufacturers' Notes

THE INTERSTATE CLAY PRODUCTS COMPANY of Cleveland, Ohio, has opened a Pacific Coast office at 401-2 White Building, Seattle. This company handles Denison interlocking tile. The office will be in charge of Albert Armstrong and H. R. Kreitzer. The former has been for eight years secretary-treasurer of the Far West Clay Company, of Tacoma, and the latter has been sales manager of the same company.

LIST OF POTASH PRODUCERS OFFERED.—Producers of potash (stone-ash or crude potash, black salts or black flux, and pearlash or white flux) obtained by the old-time method of leaching wood ashes have been writing to the United States Geological Survey and complaining of the lack of a market for their products. In view of the scarcity of potash in the United States and the need of potassium carbonate for glass and caustic for soap making, and in laundry use especially, the Survey is seeking to remedy this situation. Thirty-three producers have reported to the Geological Survey over 600 tons of these materials, valued at 7 to 70 cents a pound according to degree of refinement. This class of materials includes caustic potash, and mixtures of caustic potash, potassium carbonate, and potassium sulphate with organic and various kinds of inorganic matter. The Survey offers to act as intermediary in bringing producers and buyers of these materials together. A list of such potash and pearlash producers, particularly mentioning those who report a stock of material on hand, will be sent by the Survey to any who apply for it.

RUSSIA REQUISITIONS PLATINUM.—According to the February, 1917, issue of Russia, the requisitioning of Russian stocks of platinum by the Imperial Government is foreshadowed by an order forbidding sales of the metal, and requiring that stocks in hand be held pending further action by the authorities. The production of the Urál district in 1916 (the bulk of the world supply coming from this region) fell to between 100 and 120 poods—about one-third of the normal. Scarcity of labor checked the returns from hand-washing, and lack of spare parts for dredges interfered with the output of mechanical plants.

SARCO COMPANY, INC., maker of steam traps and temperature regulators, of Woolworth Building, New York, have added Buffalo to their list of branch offices. The new office is located at 325 Ellicott Square and is under the charge of F. D. Harger, M.E.

NEW RENNERFELT FURNACE INSTALLATION.—Hamilton & Hansell have recently sold to the Oklahoma Iron Works, Tulsa, Okla., through their Chicago representative, Glen B. Hastings, a one-ton Rennerfelt furnace, rated at 300 kw., for their new steel foundry. In addition to this, two other Rennerfelt furnaces have been sold which are going to Europe. The new and larger Rennerfelt furnace at the Parsons Company, Newton, Iowa, is now in operation. The Chicago Bearing Metal Company, Chicago, Ill., has installed two 1-ton Rennerfelt electric arc furnaces rated at 300 kw. each, for melting copper alloys.

NEW BRANCH OFFICES FOR TRAYLOR ENGINEERING.—Branch offices have been opened by John A. Traylor, western manager of the Traylor Engineering & Mfg. Company and the Cement Gun Co., with headquarters at Salt Lake City, Utah. These offices will be located at Spokane, Wash., for the Northwest district, in charge of C. H. Abeling, sales engineer, and at El Paso, Tex., for the Southwest district, in charge of Robert M. Peabody, sales engineer.

FERROZIRCONIUM AND ZIRCONIUM OXIDE.—The Foote Mineral Company's monthly publication "Mineral Foote Notes" for March contains some interesting information on ferrozirconium and pure zirconium oxide by H. C. Meyer. "This new alloy is finding a limited application in the steel industry as a scavenger for removing nitrogen and oxides from steel. One of the most recent alloys of zirconium placed on the market consists essentially of between 40 per cent and 90 per cent zirconium, with the residue mainly iron or an iron group metal. Small percentages of titanium and aluminum are also introduced. These alloys, which are covered by U. S. Patent No. 1,151,160, it is claimed are not subject to oxidation and are highly resistant to chemical reagents. They have a metallic luster and take a silvery steel-like polish. They are readily malleable and it is suggested that they may find important application in the manufacture of drawn filaments for incandescent lamps. Such filaments are claimed to have the property of selective radiation; in other words, emit more light than corresponds to the temperature at which they are heated by the electric current. This implies a considerably lower wattage per candle power than is now required by the average metal filament lamp. A typical analysis of some of the alloys produced under the above patent show: zirconium 65 per cent, iron 26 per cent, titanium 0.12 per cent, and aluminum 7.7 per cent. The production of the alloys is accomplished either by reduction with finely divided aluminum together with the mixed oxides of iron, titanium, etc., or whatever metals it is desired to introduce into the alloy; or they can be produced by heating the mixed oxides in a graphite crucible in an electric furnace, using either zircon or zirkite as a source of zirconium. An English patent, No. 29,376, covers the use of ferrozirconium as a scavenger. The alloy contains 20 per cent of the element and is used in the amount equal to about 1 per cent of the weight of steel treated. Zirconium oxide or zirconia is a pure white substance having a specific gravity of 5 and a melting point ranging from 2700 to 3000 deg. C. At the present time there are two important commercial applications of zirconium oxide: (1) as a refractory body; (2) as an opacifier or clouding agent in enamels. Various patents have been secured both in this country and abroad, covering the manufacture of refractory vessels from zirconia, for which is claimed remarkable heat-resisting properties. In one instance the pure oxide is mixed with 3 per cent to 10 per cent of magnesia, using starch, phosphoric acid, gelatinous zirconium hydroxide or borates as binders. The ware is fired in an electric furnace at a temperature ranging from 2000 to 2300 deg. C., thus producing a body which is practically impervious to all liquids and unaffected by strong acids or alkali fusions. Owing to the extremely low coefficient of expansion, such ware can be subjected to very sudden changes of temperature, in this way resembling fused silica, but unlike the latter, is not subject to devitrification. Prior to 1915 no extensive research work had been done in America on the production of pure zirconium oxide on a commercial scale, but the inability to secure the product from abroad has spurred American investigators to develop commercial processes, so that there is every promise that an oxide running 98 per cent to 99 per cent ZrO₂ will in time be placed on the market at a price

in the neighborhood of 60 cents per pound in ton lots. In the preparation of the pure oxide it is extremely important that it be practically iron-, titania- and silica-free. Iron is particularly objectionable, as it acts as a flux. A very high-grade commercially pure zirconium oxide gives the following analysis: ZrO_2, 99.91 per cent; TiO_2, 0.04 per cent; Fe_2O_3, 0.01 per cent; Al_2O_3, 0.01 per cent; SiO_2, 0.02 per cent; total 99.99 per cent. A recent European patent covers the use of zirconium oxide as a surfacing material for silica, bauxite or other refractory bricks and products. It is claimed by this process that a thin layer of zirconium oxide, with a suitable binder, renders the coated article highly resistant to slag corrosion."

RUSSIA'S FOREIGN TRADE.—*Russia* for February, 1917, gives the following data on Russian foreign trade: For nine months of 1916 the total value of Russia's foreign trade was Rs. 2,052,580,000 ($1,057,077,-700). For the same period of 1915 the total foreign trade was Rs. 987,680,000 ($505,655,200); for 1913 it was Rs. 2,078,-199,000 ($1,070,272,485). Total imports: First nine months, 1916, Rs. 1,631,403,000 ($840,172,545); 1915, Rs. 716,547,000 ($369,021,705); 1913, Rs. 1,005,629,000 ($517,898,945). Total exports: First nine months, 1916, Rs. 421,177,000 ($216,906,-155); 1915, Rs. 271,133,000 ($139,633,495); 1913, Rs. 1,072,570,000 ($552,373,550).

The Principal Imports at Vladivostok from the United States and from Japan during January-July, 1916, are shown in the figures below: From the United States: Agricultural machinery, Rs. 2,-806,000 ($1,445,090); machinery, not agricultural, Rs. 41,771,000 ($21,512,065); railroad cars and trucks, Rs. 33,545,000 ($17,275,675); cotton, Rs. 30,633,000 ($15,-775,995); steel, Rs. 25,241,000 ($12,999,-115); iron and steel manufactures, Rs. 25,-690,000 ($13,230,350); cloth, other woolen goods, Rs. 18,208,000 ($9,377,120); copper, Rs. 18,812,000 ($9,688,180); boots and shoes, 5,862,000 ($3,018,930). From Japan: Copper, Rs. 19,546,000 ($10,066,190); iron and steel goods, Rs. 19,253,000 ($9,915,295); boots and shoes, Rs. 9,481,000 ($4,892,715); cloth, other woolens Rs. 6,598,000 ($3,397,-970); knitted goods, Rs. 4,605,000 ($2,371,-575); antimony, Rs. 4,338,000 ($2,234,670); copper, manufactures of, Rs. 4,236,000 ($2,181,540); zinc, Rs. 3,903,000 ($2,010,-045); sulphur, Rs. 3,725,000 ($1,918,375); tanning extracts, Rs. 2,004,000 ($1,032,060).

POTASH FROM CALIFORNIA.—The American Trona Corporation is now producing a large quantity of potash from its refinery at San Pedro, Cal., after several years of development and research work on the Searles Lake deposit. The company is offering potassium chloride 60 to 99 per cent and natural trona containing 12 per cent sodium bicarbonate, 52 per cent sodium monocarbonate, and 6 per cent sodium chloride, balance water of crystallization. The company has a New York office at 233 Broadway, and Los Angeles, Cal., office at 366 Pacific Electric Building.

Another important addition to the potash supply of the United States comes with the development of a new field of production at Searles Marsh, in the extreme northwest section of San Bernardino County, Cal., not far from the famous Death Valley country. A large modern potash plant has just been completed by the Pacific Coast Borax and the Solvay Process companies, and operations will be begun about the first of April. It is estimated that the output will be about 1000 tons per month of muriate of potash, 80 per cent or better pure potash. A new process for the refinement of the raw product has been solved by the two companies and is reported to be very successful. The new field is included in about 1500 acres of patented land owned by the interested concerns, so that there are no obstacles to the conduct of operations once the machinery is started. Railroad facilities have been extended to the field.

BACHARACH INSTRUMENT COMPANY TAKES LARGER QUARTERS.—The Bacharach Industrial Instrument Company, Pittsburgh, Pa., formerly at 14 Wood Street, has moved into larger quarters at 422 First Avenue. The new headquarters has been made necessary by the increased demand for the company's gas meters, pressure and draft recorders, CO₂ indicators, thermometers, etc.

THE VANADIUM-ALLOYS STEEL COMPANY, of Pittsburgh and Latrobe, Pa., announce that arrangements have been completed whereby the following firms will represent them in the sale of their high speed steel, also alloy and carbon tool steel. A large stock of high speed steel in the most generally called for sizes will be carried at the various warehouses. These stocks are in addition to the stock carried by the Vanadium-Alloys Steel Company at their mill at Latrobe and their Pittsburgh warehouse. E. T. Ward's Sons, 44 Farnsworth St., Bos-

ton, Mass. Geo. Nash Company, 304 Hudson Street, New York, N. Y. Field & Company, Inc., 721 Arch Street, Philadelphia, Pa. Geo. Nash Company, 646 Washington Boulevard, Chicago, Ill.

Manufacturers' Catalogs

J. P. DEVINE COMPANY, Buffalo, N. Y., have issued an attractive little booklet dealing with Devine apparatus for the chemical and allied industries, describing autoclaves, reduction kettles, nitrating kettles, fusion kettles, chemical kettles, tilting kettles, vacuum pans, vacuum evaporators, jacketed pans, digestors, steam jacketed valves and steam jacketed pipes.

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, East Pittsburgh, Pa., have issued Catalog 5-A, January, 1917, describing Westinghouse insulating materials and supplies; Catalog 3-A, describing Westinghouse watthour meters; Catalog 3-B, describing Westinghouse instruments, switchboard, portable and precision instruments, ammeter shunts, transformers and relays, and Special Publication 1572-2-17 describing protective relays, dealing with their use on alternating current systems.

LINK-BELT COMPANY, Chicago, Ill., have issued Bulletin No. 282, dealing with the installation of Link-Belt Silent chain in chemical works.

H. REEVE ANGEL & CO., Inc., New York, has issued a booklet describing the different Whatman filter papers which it is exclusive agent for in this country.

HESS & SON, Philadelphia, have issued a booklet on "Epicassit" for tin, lead and zinc coatings, describing the different brands for the different metals.

THE SPRAY ENGINEERING COMPANY, 93 Federal Street, Boston, Mass., has issued a new bulletin, No. 501, on "Spraco" products. The bulletin gives a condensed description of the principal Spraco developments in spray cooling equipment, air washing and cooling equipment, paint spraying equipment, park sprinklers, flow meters and nozzles for general use.

Other New Publications

PRODUCTION OF COPPER, GOLD, LEAD, NICKEL, SILVER, ZINC AND OTHER METALS IN CANADA DURING THE CALENDAR YEAR 1915. This is an advance chapter of the Annual Report on the Mineral Production of Canada, 1915, published by the Canada Department of Mines, Mines Branch, Ottawa, Canada.

PRODUCTION OF CEMENT, LIME, CLAY PRODUCTS, STONE, AND OTHER STRUCTURAL MATERIALS IN CANADA DURING THE CALENDAR YEAR 1915. By John McLeish. Published by the Canada Department of Mines, Mines Branch, Ottawa, Canada.

PRODUCTION OF COAL AND COKE IN CANADA DURING THE CALENDAR YEAR 1915. By John McLeish. Published by the Canada Department of Mines, Mines Branch, Ottawa, Canada.

MINERAL PRODUCTION OF CANADA DURING THE CALENDAR YEAR 1916. Prepared by John McLeish. This is a preliminary report issued by the Canada Department of Mines, Mines Branch, Ottawa, Canada.

ANTIMONY, ARSENIC, BISMUTH, SELENIUM AND TELLURIUM IN 1915. By Frank L. Hess. Issued March 13, 1917. U. S. Geological Survey Report.

A SPECIFIC GRAVITY BALANCE FOR GASES. By Junius David Edwards. A publication of the Bureau of Standards (Technologic Paper No. 89), issued Feb. 23, 1917, by the Department of Commerce.

ANALYSES OF COAL PURCHASED BY THE GOVERNMENT, 1908-1915. By Geo. S. Pope. Bureau of Mines Bulletin 119.

YEAR BOOK FOR 1915, ILLINOIS STATE GEOLOGICAL SURVEY. Contains Administrative Report and Economic and Geological Papers. Published at Urbana, Ill., by Illinois State Geological Survey, Frank W. De Wolf, director.

SOME FACTS AND FIGURES ABOUT NORTH CAROLINA AND HER NATURAL RESOURCES. Prepared by North Carolina Geological and Economic Survey and issued at Raleigh, N. C., by the Survey.

OIL INVESTIGATIONS IN ILLINOIS IN 1916. Bulletin No. 35 of Illinois Geological Survey, Urbana, Ill.

PROPOSAL OF THE CLINTON COMMERCIAL CLUB, CLINTON, IOWA, FOR THE LOCATION OF THE GOVERNMENT ARMOR PLANT THERE. Issued by the Commercial Club, Clinton, Iowa.